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Tacubaya, Mexico, National Observatory.
Tokio, Japan, University Observatory.
Toronto, Canada, Astronomical and Physical Society of Toronto.
Toulouse, France, Observatory.
Turin, Italy, Observatory.
University Park, Colorado, Chamberlin Observatory.
University of Virginia, Virginia, McCormick Observatory.
Upsala, Sweden, University Observatory.
Vienna, Austria, Imperial Observatory.
Vienna (Ottakring), Austria, Von Kuffner's Observatory.
Washington, District of Columbia, Library of Congress.
Washington, District of Columbia, National Academy of Sciences.
Washington, District of Columbia, Naval Observatory.
Washington, District of Columbia, Smithsonian Institution.
Washington, District of Columbia, The American Ephemeris.
Washington, District of Columbia, U. S. Coast and Geodetic Survey.
William's Bay, Wisconsin, Yerkes Observatory.
Zurich, Switzerland, Observatory.

EXCHANGES.

Astrophysical Journal, William's Bay, Wisconsin.
Sirius, Cologne, Germany.
The Observatory, Greenwich, England.

FOR REVIEW.

[See *Publications*, A. S. P., vol. VIII, p. 101.]

The Call, San Francisco, California.
The Chronicle, San Francisco, California.
The Examiner, San Francisco, California.
The Mercury, San José, California.
The Record-Union, Sacramento, California.
The Times, Los Angeles, California.
The Tribune, Oakland, California.

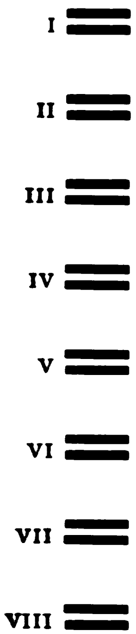
A METHOD FOR DETERMINING THE SCREW-ERRORS OF A ZENITH-TELESCOPE.

By **Frank Schlesinger.**

The zenith-telescopes in use at the four principal stations of the International Geodetic Association for Observing Variations in Latitudes are each accompanied by a double meridian-mark. By means of these, the adjustment of the azimuth-stops becomes a very simple matter and may be effected every night if necessary. In order to focus upon the marks, an auxiliary lens has been placed between the objective and ocular, and as near the latter as possible. This lens can be shunted into the optical axis whenever the meridian-marks are to be viewed; at other times it rests well to one side of the axis. This arrangement has suggested a method for examining the micrometer-screw, which has been tried at Ukiah with satisfactory results.

In the present case the meridian-marks are 55.5 meters (182 feet) north of the telescope; upon the small structure which serves to shelter them was fastened a vertical scale divided into seven nearly equal spaces. Each of these spaces was of such a length as to correspond approximately to one revolution of the micrometer-screw when the auxiliary lens was in position. The total length of the scale was actually 130^{mm}, each space being about 18.5^{mm}. It is not necessary in the method to be described that the scale be accurately divided. It was found that an entirely adequate scale could be ruled on drawing-paper with india-ink, like the one shown in the accompanying sketch. The division-marks were made double, and could be nicely bisected by the single thread of the micrometer. The screw has an effective length of twenty-eight revolutions. As it would be impractical to examine the whole screw at once, it was divided into four equal portions, and each of these was investigated separately. The method used to do this is an adaptation of that developed by Gill, Lorentzen, and others. A clear account of this method is given by Professor Harold Jacoby in the *American Journal of Science* for May, 1896.

The micrometer having been set at about $1^{R}.0$, the telescope was pointed so that the micrometer thread coincided as nearly as possible with Division VII of the scale. Readings were made



upon this division, and also upon Division VIII, care being taken not to move the telescope between the two sets. The micrometer having been set back to $1^R.0$, the telescope was pointed at Division VI. Readings were then taken on Divisions VI, VII, and VIII. In this way the operations were continued until each space of the scale had been measured with each turn of the micrometer from $1^R.0$ to $8^R.0$. These measures furnish data from which the errors of both screw and scale can easily be computed. The three other parts of the screw were treated in an entirely similar manner; so that it only remained to determine the errors at 8^R, 15^R, and 22^R. This was done by measuring the total length of the scale with the four parts of the screw in succession. Throughout the work all operations were immediately repeated in reverse order, to provide as far as possible against changes in the telescope, in the observer, or in the scale.

Such an investigation as has been described was made at Ukiah and repeated until at least four determinations of each screw-error had been obtained. A comparison of the separate results gives only 0".025 for the probable error of a single determination. I give below a list of the definitive corrections. It will be noticed that they are small and that they run very smoothly, there being no abrupt change except at the extreme end of the screw. The units are hundredths of a second:—

R.	Corr.	R.	Corr.	R.	Corr.	R.	Corr.
1 . . .	−1	8 . . .	+4	15 . . .	+2	22 . . .	+3
2 . . .	0	9 . . .	+4	16 . . .	−2	23 . . .	−3
3 . . .	−5	10 . . .	+5	17 . . .	−1	24 . . .	−4
4 . . .	−4	11 . . .	+5	18 . . .	−2	25 . . .	−8
5 . . .	−4	12 . . .	+4	19 . . .	−2	26 . . .	−8
6 . . .	−3	13 . . .	+2	20 . . .	−2	27 . . .	−5
7 . . .	+1	14 .	+2	21 . . .	+2	28 . . .	+4
						29 . . .	+12

If it be desired to use this method for determining the periodic as well as the progressive errors, a scale should be used whose total length corresponds to one turn of the screw and which is divided into four or five equal parts.

The auxiliary lens is not strictly necessary, as the vertical scale may be brought into focus by drawing out the ocular. In this case, however, it is not advisable to examine the screw concurrently with the latitude-observations, as the constants of the instrument are liable to disturbance.

The method which has been almost exclusively employed for determining the screw-errors of a zenith-telescope is that afforded by elongations of close circumpolar stars. The weak point in this method is the dependence upon the latitude-levels. A complete elongation of *Polaris* or of λ *Ursæ Minoris* occupies more than an hour for a telescope with a field of twenty minutes of arc. Latitude-levels, even under favorable circumstances, cannot be depended upon to maintain a constant angle with the telescope for so long a time. Moreover, during an elongation the observer must remain at one end of the levels—just the position in which the heat from his body is likely to warp them. It is this circumstance probably, to which are due the inaccurate results sometimes obtained by the method of elongations.

In his "Anleitung zum Gebrauche des Zenitteleskops" (Berlin, 1899), Doctor ALBRECHT has recommended the use of an auxiliary micrometer, to be fixed at the eye-end of the telescope. The errors of both screws can thus be determined simultaneously. In this method the optical system during the examination of the screw is entirely different from that used for the latitude observations, and slight systematic errors may creep in. This objection also applies, but in a lesser degree, to the method of this paper. The latter has the additional advantages of greater convenience and in requiring practically no auxiliary apparatus.

INTERNATIONAL LATITUDE OBSERVATORY,
Ukiah, California, 19 November, 1901.

PLANETARY PHENOMENA FOR MARCH AND APRIL, 1902.

By MALCOLM MCNEILL.

MARCH.

The Sun crosses the equator from south to north on March 21st, 5 A.M., Pacific standard time.

Mercury is a morning star, and comes to greatest west elongation on March 17th. Although its distance from the Sun at this time is 28° nearly, 10° more than it was at the east elongation in February, the planet is so far south of the Sun that the conditions for visibility are not very good. However, for the first twenty days of the month it rises about an hour before sunrise, and may be seen, if the weather conditions are exceptionally good, in the morning twilight.

Venus passed inferior conjunction on February 14th, and moves rapidly away from the Sun, so that by March 1st it rises about an hour and a half before sunrise. It ceases to move westward among the stars, and begins its longer eastward motion on March 6th; so its rate of recession from the Sun diminishes rapidly. At the end of the month it rises about two hours before sunrise. It will be very bright throughout the month, and will be at maximum brilliancy on March 21st. At this time it is about half-way between inferior conjunction and greatest elongation.

Mars is very near the Sun throughout the month, and on March 29th is in superior conjunction, becoming a morning star. Owing to the eccentricity of its orbit, this time of conjunction does not coincide with the time of maximum distance from the Earth. This does not occur until the latter part of May. The planet is about at its faintest, and will not brighten up much for several months.

Jupiter is getting far enough west of the Sun to be seen in the morning twilight. Its time of rising on March 1st is about the same as that of *Venus*, but it is considerably farther south. It moves about 6° eastward in the constellation *Capricorn*.

Saturn rises nearly an hour before *Jupiter*, and its distance from the latter increases from 11° to 15° during the month. It moves about 2° eastward in the region between *Sagittarius* and *Capricorn*.

Uranus rises not long after midnight. It is in the lower extension of *Ophiuchus*, between *Scorpio* and *Sagittarius*.

Neptune is in the extreme western part of *Gemini*, and is above the horizon until after midnight.

APRIL.

There will be two eclipses during April, neither of them visible in the United States.

The first is a partial eclipse of the Sun on April 8th, visible only in the northern parts of America and Asia. The maximum obscuration of the Sun will be only .06 of its diameter.

The second is a total eclipse of the Moon on April 22d, not visible in the western hemisphere.

Mercury is a morning star until April 28th. It then passes superior conjunction, and becomes an evening star, but throughout the month remains too near the Sun to be seen with the naked eye.

Venus is still the most conspicuous object in the morning sky. It rises about two hours before the Sun throughout the month. It comes to its greatest west elongation, 46°, on April 25th. The interval between rising of the Sun and planet is much shorter than it usually is at time of greatest elongation, on account of the fact that *Venus* is far south of the Sun at the time.

Mars is entirely too near the Sun and too faint to be seen during April. It is in the morning sky, but by the end of the month it is only 6° west of the Sun, and rises less than twenty minutes earlier.

Jupiter by the end of April rises at about half after one o'clock, and is therefore in a position for easy observation for early risers. It moves about 4° eastward in the constellation *Capricorn.*

Saturn rises about an hour before *Jupiter.* It is in the western part of *Capricorn* and is still moving eastward, but with a much slower motion than that of *Jupiter*, only 1° during the month.

Uranus keeps about the same place. It ceases its eastward motion during March, and is now slowly moving westward.

Neptune remains in the western part of *Gemini.*

MARCH–APRIL, 1902.

PHASES OF THE MOON, P. S. T.

Last Quarter . . .	Mar. 2,	2^h	39^m	A. M.
New Moon . . .	Mar. 9,	6	50	P. M.
First Quarter . . .	Mar. 16,	2	13	
Full Moon . . .	Mar. 23,	7	21	
Last Quarter . . .	Mar. 31,	10	24	
New Moon . . .	Apr. 8,	5	50	A. M.
First Quarter . . .	Apr. 14,	9	26	P. M.
Full Moon . . .	Apr. 22,	10	50	A. M.
Last Quarter . . .	Apr. 30,	2	58	P. M.

THE SUN.

1902.		R. A.	Declination.	Rises.	Transits.	Sets.
Mar.	1,	22^h 46^m	— 7° 49′	6^h 39^m A.M.	12^h 13^m P.M.	5^h 47^m P.M.
	11,	23 23	— 3 58	6 23	12 10	5 57
	21,	0 0	— 0 1	6 8	12 8	6 8
	31,	0 36	+ 3 54	5 51	12 4	6 17
Apr.	10,	1 13	+ 7 42	5 36	12 2	6 28
	20,	1 50	+ 11 17	5 20	11 59 A.M.	6 38
	30,	2 27	+ 14 34	5 7	11 57	6 47

MERCURY.

Mar.	1,	21 30	— 12 24	5 39 A.M.	10 56 A.M.	4 13 P.M.
	11,	21 42	— 13 40	5 15	10 28	3 41
	21,	22 21	— 11 57	5 9	10 28	3 47
	31,	23 11	— 7 45	5 6	10 40	4 14
Apr.	10,	0 10	— 1 30	5 4	10 59	4 54
	20,	1 17	+ 6 25	5 5	11 26	5 47
	30,	2 34	+ 15 6	5 12	12 4 P.M.	6 56

VENUS.

Mar.	1,	21 13	— 7 45	5 6 A.M.	10 40 A.M.	4 14 P.M.
	11,	21 13	— 9 18	4 32	10 0	3 28
	21,	21 27	— 9 59	4 9	9 35	3 1
	31,	21 52	— 9 38	3 53	9 20	2 47
Apr.	10,	22 23	— 8 18	3 40	9 12	2 44
	20,	22 58	— 6 8	3 28	9 8	2 48
	30,	23 35	— 3 15	3 14	9 5	2 56

MARS.

Mar.	1,	23 11	— 6 18	6 18 A.M.	12 37 P.M.	6 16 P.M.
	11,	23 39	— 3 10	6 36	12 26	6 16
	21,	0 8	— 0 0	6 15	12 15	6 15
	31,	0 36	+ 3 9	5 54	12 4	6 14
Apr.	10,	1 4	+ 6 12	5 33	11 53 A.M.	6 13
	20,	1 33	+ 9 8	5 13	11 42	6 13
	30,	2 1	+ 11 54	4 50	11 31	6 12

JUPITER.

Mar.	1,	20 30	— 19 22	5 6 A.M.	9 57 A.M.	2 48 P.M.
Apr.	1,	20 55	— 17 53	3 35	8 20	1 5
May	1,	21 12	— 16 46	1 37	6 39	11 41 A.M.

SATURN.

Mar.	1,	19 45	— 21 9	4 27 A.M.	9 12 A.M.	1 57 P.M.
Apr.	1,	19 55	— 20 45	2 34	7 20	12 6
May	1,	19 59	— 20 35	12 39	5 26	10 13 A.M.

URANUS.

Mar.	1,	17 21	— 23 12	2 12 A.M.	6 48 A.M.	11 24 A.M.
Apr.	1,	17 22	— 23 13	12 11	4 47	9 23
May	1,	17 20	— 23 12	10 7 P.M.	2 43	7 19

NEPTUNE.

Mar.	1,	5 54	+ 22 17	noon.	7 20 P.M.	2 40 A.M.
Apr.	1,	5 55	+ 22 18	9 58 A.M.	5 18	12 38
May	1,	5 57	+ 22 20	8 3	3 23	10 43 P.M.

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off left-hand limb as seen in an inverting telescope.)

I, D,	Mar.	6,	6^{h}	19^{m} A.M.
II, D,		12,	3	21
I, D,		15,	2	42
IV, D,		15,	5	9
II, D,		19,	5	56
I, D,		22,	4	36
III, D,		22,	5	26
I, D,		31,	12	58
IV, R,	April	1,	3^{h}	31^{m} A.M.
II, D,		6,	12	22
I, D,		7,	2	52
I, D,		13,	2	50
I, D,		14,	4	46
III, R,		20,	12	51
II, D,		20,	5	30
I, D,		23,	1	8
III, D,		27,	2	23
III, R,		27,	4	51
I, D,		30,	3	2

HUSSEY'S MEASURES OF THE OΣ DOUBLE STARS.*

By S. W. Burnham.

One of the most important and interesting contributions of practical astronomical work has just been issued by the great Observatory at Mt. Hamilton, as Volume V of the *Publications of the Lick Observatory.* This quarto volume of 227 pages contains the reobservation and measurement by Professor Hussey of all the double stars of the first edition of the Poulkowa Catalogue of 1843. Each of the pairs has been measured on an average of three nights with either the 12-inch or the 36-inch refractor, the most difficult of these objects, of course, being observed with the large instrument. The measures were made principally from 1897 to 1900, and, for the most part, all the measures of each star were made in the same year. It is well known that in the second edition of 1850 of the Poulkowa Catalogue many of the stars of the first catalogue were rejected,—some because the suspected elongation was not confirmed by subsequent examinations, some because the companion-star was too distant, and some because they had been found to be identical with previously known pairs in the catalogues of W. Struve, Herschel, and others. These rejected numbers amount altogether to 106 stars. The original number of the OΣ stars was 514, but other new pairs were found from time to time, and the total number was finally extended to 547.

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*Reprinted from *Popular Astronomy* for December, 1901.

HUSSEY has accounted for all these stars, rejected and otherwise, and arranged them in this general catalogue in numerical order, with a table at the end of the volume giving them in order of Right Ascension with positions for 1900, so that any star can be found by its number or place. He has collected with remarkable thoroughness substantially all the published measures of each pair, and placed them in chronological order, with a reference to the place of publication. One can see at a glance whether or not there is any relative motion, and generally what the change is in the last sixty years, where there is change in the components from proper or orbital motion. The notes accompanying each star are complete, and give all that is worth mentioning concerning the character and history of the pair. They are models of completeness for brevity. When necessary they are illustrated by diagrams showing the relative change in the components.

The pairs rejected as single have all been carefully examined with the great telescope, and in each instance no elongation detected under favorable conditions. Many of these stars had been previously examined by the writer with the same telescope and with Chicago 18½-inch with the same result, but it is always possible that a star of this class may be really double, though so close from the rapid motion of the components that at a given time it is single with the largest aperture. As many of these stars have been watched more or less at intervals in the last thirty years, without showing any signs of duplicity, in first-class refractors, it is safe to say that in all probability the orginal observations which led to their being placed in the Poulkowa Catalogue was a mistake, and the supposed elongation not real.

Of the other class of wide pairs, although not likely to be of any interest as physical double stars, many of them were in need of measurement, as some depended upon perhaps a single observation of MADLER made more than half a century ago. Some of them were placed on the working list of neglected pairs prepared by the writer for observation at the Yerkes Observatory, not knowing at that time that HUSSEY'S plan embraced all these stars. My work in this direction was, of course, discontinued after receiving this volume, as there would be no excuse for duplicating work already so carefully and well done.

In the course of these observations Professor HUSSEY found new components to five of the Poulkowa stars, and two of these, OΣ 351 and OΣ 476, seem to be remarkable objects visually, and likely to be remarkable hereafter as physical systems. The known components of the first pair are only 0″.6 apart, while one of them is composed of two stars, with a distance of only 0″.3. In the other case the OΣ components have a distance of 0″.54, and the smaller of these is a close pair, with a distance of 0″.15. These are the closest triple stars known, and are certain to be interesting physical systems, and perhaps in rapid motion. Discoveries of this kind must necessarily be made with large refractors, and while it is possible that these stars are more readily seen now than heretofore, it is certain that they are beyond the grasp of all, or nearly all, the instruments used for the measurement of these stars in former years.

The Director of Lick Observatory and the authorities of the University of California have earned the thanks of the astronomical world for the prompt publication of this beautiful volume. The printer's work has been so well done that it may be said to represent the highest art in this class of composition. The arrangement of the matter and the selection of the various kinds of type make a volume both convenient and pleasant to use. The plan generally is that adopted in the General Catalogue of the β stars, issued as Volume I of the *Publications of the Yerkes Observatory*.

This volume will practically take the place of all former works relating to this subject-matter, since it contains all that is needed in the earlier catalogues and publications. It should prevent hereafter much waste of time in duplicating measures, and observing pairs for which no measures, for many years, are needed. The stars which are shown to be relatively fixed, or where the change is slow, will need no further attention for at least a quarter of a century. On the other hand, those in rapid orbital motion should be measured by one of the large telescopes at short intervals, some of them every year. For some of these binaries new orbits have been computed, based upon the new and later measures. Among others is an orbit of δ *Equulei*, from which it appears that a period of 5.7 years will satisfy the measures as well or better than the 11.4-year period heretofore supposed to be the true time. Should this shorter period prove to be correct — and the prima facie case made seems to be a strong one — it will be the most rapid binary now known. If this pair is carefully watched and measured several times each year when the apparent motion is most rapid, as it doubtless will be at Mt. Hamilton, it will not require long to determine which of the periods is correct. It is fortunate that micrometrical work, and especially that relating to double stars, is in the hands of two such zealous and expert observers as HUSSEY and AITKEN.

One can imagine the pleasure with which the venerable OTTO STRUVE will examine this work, which brings together for the first time in a perfect and permanent form his great discoveries of more than half a century ago. At this time in his life, when his work with the telescope has been concluded, he cannot fail to appreciate the value of this volume as a permanent monument to his memory.

NOTICES FROM THE LICK OBSERVATORY.*

Prepared by Members of the Staff.

FURTHER OBSERVATIONS OF THE NEBULA ABOUT *NOVA PERSEI.*

Since the photograph of November 7–8th, five other negatives have been secured with the Crossley reflector, as follows:—November 12–13th, December 4th, December 8th and 11th, January 2–3d and January 10–11th. With the exception of that of December 4th, all have had exposures of ten hours. These later photographs have been obtained on quicker plates, and with the longer exposures, much more detail is shown than on the first.

These negatives show two distinct regions of nebulosity to exist about the *Nova.* The region about the star within a radius of 7′ is filled with nebulosity showing much detail. It is in this region where the condensations are situated which were first observed to be in rapid motion. Outside of this circular region of 15′ diameter is a ring of very much fainter nebulosity, having an extreme diameter of 30′. This nebulosity is so faint, in fact, that, with the exception of a few of the brighter wisps, it is not visible until intensified by successive copyings on slow plates. This method of bringing out faint contrasts is one well known to experienced photographers and has long been in use at this Observatory.

The motions which were observed in some of the brighter condensations are shown by the later photographs to continue. These motions are not radial, although the entire circle of nebula is expanding. Some of the observed motions are clockwise, while others appear to be moving in the opposite direction.

With the exception of two groups of filaments in the faint outer ring of nebulosity, there is not sufficient structure there for a satisfactory determination of motions. Of the two masses mentioned, one shows a clockwise motion and the other a counter-clockwise motion of about 3′ in the interval of a month between the December and January observations. The larger proportion of motion is tangential, the radial component amounting to nearly 1′. Neither of these two groups of nebulosities was visible on the photograph of November 7–8th. One of them shows very faintly on the negative of November 12–13th, the other on a negative with only 5½ hours' exposure on December 4th. The later negatives all show both groups. Some exceedingly fine structural detail is also shown on the later negatives in the extreme outer portion of this outer ring, to the west of *Nova*. This detail is composed of the finest threadlike filaments, and in this also can be traced a general outward movement.

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* **Lick Astronomical Department of the University of California.**

In examining the earlier short-exposure negatives of the *Nova* for another purpose, I found one, taken on March 29th with an exposure of ten minutes, which shows a complete ring of faint nebulosity about the *Nova*. These photographs were obtained by Messrs. H. K. PALMER and C. G. DALL while the writer was absent on the Eclipse Expedition to Sumatra.

This photograph carries back our knowledge of the nebula nearly five months. The earliest observations previously known were by Professor MAX WOLF, on August 23d, and Mr. RITCHEY, of the Yerkes Observatory, on September 20th.

The ring of nebulosity shown on the negative of March 29th is not perfectly circular, but is flattened on the southwest side. The longer axis of the oval is in the direction southeast-northwest, and is about 5′ in length. The ring is approximately 20″ in width in the best-defined portions. The nebulosity at the ends of this oval is much more diffuse and broadened and resembles somewhat the Annular Nebula in *Lyra*. Inside this ring and very close around the star is an elliptical ring of much fainter nebulosity whose major axis is in position-angle 60°. The *Nova* occupies the southwest focus of this ellipse, whose major axis is 2½′ in length and its minor axis 2′.

A narrow circular arc of nebulosity extends from position-angle 0° to 90° at a distance of 5′ from *Nova*, which occupies the center of curvature.

Besides the features described, there is a series of faint envelopes to the south of the star, at a distance of 3′, which has an arrow-shaped form pointing to the east. There are also some faint masses of nebulosity to be seen inside the larger ring. As the later observations showed the outer ring of nebulosity to be expanding at about the rate which would have carried the ring of March 29th to its present position, the assumption of probable identity was made and the velocity of recession radially from the star determined. This was possible from two well-defined masses on the outer rim of the large exterior nebulosity, using the interval March 29, 1901, to January 2–3, 1902. One of these masses was southwest of *Nova*, the other north. The mass to the southwest gave a velocity of 3″.00 per day; the mass to the north gave a velocity of 2″.62 per day. These velocities carry their respective nebulosities (both rings) back to the *Nova* on February 17th and 16th. Each pair of results agrees within a small fraction of a day, which must be considered largely accidental owing to the uncertainties of measuring such objects. Many of the condensations are growing fainter, owing, probably, to the general expansion. Condensation A was very compact when first observed on November 7–8th. It has now separated into three envelopes, the whole being much fainter. Several new masses have appeared in its vicinity. Condensation D seems to have remained unchanged either in intensity or form, since November 7–8th.

We may summarize briefly the results of a comparison of all our negatives, as follows:—

Great changes are still going on in the nebulosity about the *Nova*. Some masses appear to be growing brighter, while others are growing fainter.

The nebulosity is found chiefly in two regions. The brighter is situated in a circular area 15′ in diameter, in which *Nova* occupies the center. Around this region is a ring of much fainter nebulosity 30′ in diameter. Both of these regions are expanding rapidly in all directions. Many portions of the nebula are in rapid motion. Several of the condensations appear to have a spiral motion, some clockwise, others the reverse. No entirely radial motion has been observed. The nebulosity now visible appears to have been expelled from the region of the star about February 16th or 17th (neglecting light transmission) in the general form of rings or shells.

If this nebulosity is moving in all directions at its present rate of speed, and should continue at this rate, some of it should reach the solar system in 250 years or less.

Messrs. H. K. PALMER and JOEL STEBBINS, Fellows in Astronomy, have assisted in taking the later photographs with the Crossley reflector. C. D. PERRINE.

MT. HAMILTON, CALIFORNIA, 1902, January 15.

OBSERVATIONS OF 194 DOUBLE STARS.

My double-star observing-list for the years 1900 and 1901 was made up largely of the more rapid binaries and other difficult pairs taken principally from the catalogues of BURNHAM, HOUGH, and the CLARKS.

About six hundred measures of one hundred and ninety of these stars, besides notes on four that were found to be single, have been published as Bulletin No. 11 of the Lick Observatory. Of the measured pairs, ninety-four have distances of 0″.5 or less, including some of the closest pairs known; forty-two more have distances ranging from 0″.5 to 1″.0, and, of the wider pairs, many are difficult, by reason of the faintness of the smaller star. The great majority of the measures were made with the 36-inch telescope.

The double-star system that is of greatest interest at present is δ *Equulei* = OΣ 535. My observations of this pair made in 1900 were printed in No. 76 of these *Publications*, and the first two secured in 1901, in No. 79. In May, June, and July measures were made without special difficulty, the angular separation of the components reaching a maximum of about 0″.15.

During September and October the apparent distance between the two components again began to grow smaller and measures became more difficult. The star was followed carefully as long as it was in reach, the last observation being made on December 19th. On that date, the highest power eye-piece for the 36-inch telescope showed no certain elongation. The seeing was very good. These observations, confirmed as they are by those made by Professor HUSSEY, seem to present conclusive evidence in favor of the 5.7-year period of revolution. It is certain that the companion moved out to elongation and in again in little more than a year's time.

R. G. AITKEN.

January 15, 1902.

DUPLICITY OF THE PRINCIPAL COMPONENT OF Σ 238.

A recent examination of this pair with the 36-inch telescope revealed the existence of a close companion to the brighter star. The mean of three nights' measures is:—

1902.00 108°.1 0″.85 8.3 - 10.7

My measure of the Struve pair is —

1901.970 356°.9 10″.83 1ⁿ

which agrees almost exactly with STRUVE's measure made in 1830, showing that the wide pair is fixed.

R. G. AITKEN.

January 15, 1902.

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in carrying out the work of this department. Communications of general interest will be gladly received, and may be sent to SIDNEY D. TOWNLEY, 2023 Bancroft Way, Berkeley, California.

Mr. JOHN A. BRASHEAR, the well-known optician, has been elected Chancelor of the University of Western Pennsylvania.

CHARLES A. BACON, professor of astronomy in Beloit College, Wisconsin, and director of Smith Observatory, died November 6, 1901.

The report of the Board of Visitors of the United States Naval Observatory has been published in *Science*, December 6th. Extracts from the report of the Superintendent of the Naval Observatory, with some editorial comments, are printed in the issue of the same journal for December 20th.

At the meeting of the Astronomical and Astrophysical Society of America held in Washington, D. C., December 30, 1901, to January 3, 1902, the following officers were elected: President, SIMON NEWCOMB; First Vice-President, G. E. HALE; Second Vice-President, W. W. CAMPBELL; Treasurer, C. L. DOOLITTLE; Councilor, E. C. PICKERING; Councilor, R. S. WOODWARD.

The next meeting of the Society will be held at Washington, in December, 1902.

At a meeting of the National Academy of Sciences at Washington in April, Professor S. P. LANGLEY read a paper reviewing his work in the investigation of the solar spectrum, the paper being a summary of the results embodied in Volume I of the *Annals of the Astrophysical Observatory of the Smithsonian Institution*. As illustrating the principal feature of the work, a map was shown of the solar spectrum, only a small part of which, on the left, was the visible spectrum known to Sir ISAAC NEWTON. This was the familiar colored spectrum. The remainder consisted of the extended range of the solar energy invisible to the eye, but which by the researches of Professor LANGLEY was now mapped with the variations of energy shown by curves.

The visible spectrum, from a little beyond the violet, at a wave-length of somewhat less than 0.4μ, down to the extreme red, which is considered to terminate at the almost invisible line A, whose wave-lenghth is 0.7μ, has been the seat of prolonged spectroscopic investigation. On a scale of the actual wave-length of light, where the unit of measurement ($1\ \mu$) is one one-thousandth of a millimeter, the length of the visible spectrum is $0.36\ \mu$. This prominence of the visible spectrum is due partly to the reason that it is visible, and partly to the fact that the ordinary prism gives an immensely extended linear depiction of the really small amount of energy in this visible part. The region beyond the violet has also received undue attention from the fact that the salts of silver used in photography are extremely sensitive to the short wave-length rays of this portion, although this portion is lacking in energy.

On the map shown, a scale had to be adopted for the spectrum, which has really no positive dimension, being extended at one end or the other, according to the use of the prism or grating employed in producing it. The scale used was such that the infra-red portion of the spectrum, as given by a rock-salt prism, was correct. The visible and ultra-violet given was not exact; for on the prismatic scale it would have taken nearly 100 feet of map to depict, although the ultra-violet really contains much less than one one-hundreth part of the total solar energy, and the visible spectrum but about one fifth. The only law which governs is that the amount of energy in any region of the spectrum, such as that in any color, or between any two specified limits, is a definite quantity fixed by facts independent of our choice, such as the nature of the radiant body or the absorption which the ray has undergone.

Everything in linear presentation, then, depends on the scale adopted. If the lengths be proportional to the energies, the familiar prismatic representation enormously exaggerates the importance of the visible and still more of the ultra-violet region, and similarly the grating spectrum exaggerates that of the infra-red region. On the adopted scale, the visible spectrum had been drawn on the average dispersion of the infra-red.

Of the invisible region beyond the infra-red, nothing was known until 1800, when Sir WILLIAM HERSCHEL found heat there with a thermometer, although this region contains four fifths of the solar energy. Sir JOHN HERSCHEL determined that the heat was not continuous; but it was not until 1871, when LEMANSKY made a drawing of the energy-curve (which, being without scale, is indeterminate), that much was known regarding this region. Three depressions are shown in his curve, indicating lapses of heat in the infra-red. They probably indicate something near to a wave-length of 1 μ. It was this drawing that first interested Professor LANGLEY in the subject.

Prior to 1885 the true wave-lengths were imperfectly known, but were then determined by Professor LANGLEY as far as the end of what he has called the "New Spectrum," at a wave-length of 5.3 μ. After this the next important addition to the subject was made by Captain ABNEY, who gave the photographic spectrum down to 1.1 μ.

The predecessors of Professor LANGLEY had worked with the thermopile, which was insufficient in the feeble heat of the grating-spectrum for good results. This led to his invention of the bolometer, about 1880. The basic idea in this instrument is the formation of a Wheatstone bridge. The variation in conductivity of one arm of the bridge, due to a variation in temperature, while the other arm of the bridge is of a constant temperature, can be measured by a galvanometer. As constructed, the two arms of the bridge are formed by two platinum tapes, one exposed to the heat and the other screened. The width of tape in some bolometers is one two-hundred-and-fiftieth of an inch and its thickness but one tenth of its width. With the improvements introduced in the attending galvanometer by Mr. ABBOTT, it is now possible to register changes in temperature of one one-hundred-millionth of a degree, with an error of less than two one-hundredths of one per cent.

With this sensitive instrument it is possible to locate the invisible lines with an accuracy equal to that of refined astronomical measurements. The action of the bolometer can be compared to an eye that sees in the dark. The solar energy is everywhere the same, and is "light" or "heat" only in accordance with the organ that interprets it. Hence lines like the dark Fraunhofer lines in the visible spectra appear to the bolometer as cold bands, and this hairlike strip of platinum is moved along in the invisible part of the spectrum till the galvanometer indicates the all but infinitesimal change of temperature caused by its contact with such a "cold band."

The first method of observation was extremely slow and tedious, as it required hundreds of observations by three persons to determine with appropriate accuracy the position in wave-length of one invisible line. It took two years to map about twenty such lines, and it was possible that a thousand lines existed.

After twelve years of experimenting, an automatic apparatus has been devised which registers in an hour the lines which would have taken half a century to register by the first method.

Briefly, the method is this: A great rock-salt prism (for a glass one would not transmit these lower rays, nor could they easily be detected in the overlapping spectra of the grating) is obtained of such purity and accuracy of figure, and so well sheltered from moisture, that its clearness and its indications compare favorably, even in the visible spectrum, with those of the most perfect prism of glass, with the additional advantage that it is permeable to the extreme infra-red rays in question. This prism rests on a large azimuth-circle turned by clockwork of the extremest precision, which causes the spectrum to move slowly along, and in one minute of time, for example, to move exactly one minute of arc of its length before the strip of the bolometer, bringing this successively in contact with one invisible line and another. Since what is blackness to the eye is cold to the bolometer, the contact of the black lines chills the strip and increases the electric current. The bolometer is connected by a cable with the galvanometer, whose consequent swing to the right or the left is photographically registered on a plate which the same clockwork causes to move synchronously and uniformly up and down by exactly one centimeter of space for the corresponding minute. By this means the energy-curve of an invisible region, which directly is wholly inaccessible to photography, is photographed upon the plate.

The number of lines in the infra-red spectrum is over seven hundred, and exceeds the number of visible ones in Kirchoff and Bunsen's charts.

In this way the spectrum of solar energy, which has been discovered by the French observers to extend to 1.8μ, and to which Dr. JOHN DRAPER had set, from theoretical considerations, a limit of a wave-length of 1μ, has now been discovered and mapped by Professor LANGLEY to a wave-length of 5.3μ. The region between 1.8μ and 5.3μ he has termed the "New Spectrum."

One result obtained by these investigations is that, under similar conditions as to altitude and atmosphere, the amount of solar energy varied with the season. Since all life on the Earth depends for its existence on the Sun's energy, it follows that by this means some record might be made of varying solar energy and predictions made of the character of the seasons, and a consequent benefit secured therefrom for humanity. J. D. G.

Continuing the plan inaugurated two years ago, letters were recently sent to the directors of the chief observatories of the Pacific Coast, asking for a statement of the work accomplished during 1901. From the answers received the following accounts have been written:—

CHABOT OBSERVATORY. — Mr. BURCKHALTER writes as follows:—

"In answer to the request of the Committee on Publication, I have very little to report of value in the way of original work for the past year. The observatory was given to the Board of Education of Oakland for popular instruction to the public and schools, etc., and, as the observavatory has always been exceedingly popular, the assistant in charge also being required to give a half-day to school-work, scarcely any time is left for original work. All my spare time the past year was taken up in supervising and devising certain parts of the new Assembly Hall just added to the observatory, for which I was held responsible"

INTERNATIONAL LATITUDE OBSERVATORY. — Dr. SCHLESINGER'S report of the work accomplished at this observatory is as follows:—

"The programme of the International Geodetic Association for Observing Variations of Latitude has been continued without modification at this station, as well as at the five others, throughout 1901. Below is given a summary of the observations made here during the year.

"I. *Observations for latitude proper.*— The following table gives the number of nights and the number of pairs observed in each month:—

1901.	January	14 nights	123 pairs.
	February	10 "	123 "
	March	18 "	153 "
	April	17 "	169 "
	May	17 "	167 "
	June	15 "	187 "
	July	14 "	170 "
	August	15 "	192 "
	September	13 "	146 "
	October	15 "	187 "
	November	12 "	135 "
	December	15 "	163 "
	Totals	175 nights	1,915 pairs.

"II. *Observations for the control of the position of the instrument.*—Owing to the admirable stability of the zenith-telescope and of the meridian-marks, these observations were made only once in about two months. No appreciable error in the latitude would have been incurred if such observations had been omitted altogether during the year.

"III. *Observations for values of the level-spaces.* — One series for this purpose was made during the summer.

"IV. *Observations for micrometer-value.* — The *Pleiades* were observed on every possible occasion during January. One elongation of *Polaris* was observed for the same purpose.

"V. *Observations for screw-errors.* — The *periodic* errors of the micrometer-screw are being examined by the same method as that used for the *progressive* errors. This method is described on other pages of this number.

"No definitive reduction of the observations at the six latitude stations has yet been published. A preliminary discussion including all observations up to January, 1901, will be found in the *Astronomische Nachrichten*, No. 3734."

LICK OBSERVATORY. — Owing to his absence in the East to attend the meeting of the Astronomical and Astrophysical Society of America, Director CAMPBELL finds it impossible to prepare a report for this number of the *Publications*.

MOUNT LOWE OBSERVATORY. — Professor EDGAR L. LARKIN'S account of the work accomplished at this observatory is as follows:—

"The writer assumed directorship of this observatory on January 1, 1901. The year has been one of confusion in building, painting, and putting in electric lights, so that extensive observations have not been made. A new science hall has been added to the building — mostly for spectroscopic and other optical work — and a new covering put on the dome.

OBSERVATIONS, 1901.

January 10th	GIACOBINI'S comet.
February 25th . . .	The new star in *Perseus*.
May 17th and 18th . .	The Australian comet.
August 14th	ENCKE'S comet.
November 15th . . .	The Leonid meteors — 661 recorded.
November 27th . . .	Conjunction *Jupiter* and *Saturn*.
Since July	The sodium lines.
During the year . . .	The stellar floor.
The year	Standard thermometer, barometer, and rain-gauge.

"Since the Brashear spectroscope was mounted in its new room in July, a preliminary study has been made of the two sodium lines and adjacent regions. The heliostat was a home-made affair, bad beyond comparison. A new one of perfect workmanship is now on the way from BRASHEAR. The spectrum has been examined often at precise instants of sunrise, when the Sun's limb is rising over bare rock on the summits of the mountains, or emerging from thickets of manzanita shrubs; also at instants of sunset both in the sea and over rocks capping the coast ranges. No interpretation is offered. The dust question is looming up in spectroscopy; and the silicious sheets sent hither by the Mojave Desert make havoc with solar rays and quench their waves. Often eleven lines are seen between D_1 and D_2, from five to fifty between D_2 and D_3, and as many more on the opposite side of D_1 to an equal distance. These phenomena must be studied a year after the arrival of the new heliostat before anything of value is derived from the research, if at all. The spectrum of *Nova Persei* secured here on February 25th is well represented by figure 1, following page 232, No. 81, these *Publications*."

Mr. LARKIN has also interested himself in a study of the sky on dark clear nights. The mountain station has a particular advantage for such work as this, as the observer is usually far above the dust-laden atmosphere of the lower levels. Mr. LARKIN'S report of the work is unfortunately too long to reproduce here, but the nature of the results obtained is indicated by the following sentence:—

> "The entire background of *Orion*, as seen here, is either a complete nebula or an incredible number of excessively minute stellar points. After a rain and on the clearest, darkest nights, *Orion* is always bound in white, while at the same time other portions of the celestial vault are jet black between the stars."

STUDENTS' OBSERVATORY.—The special announcement to students mentioned in the report of last year has been printed and distributed. It gives a description of the instrumental equipment of the Lick and Students' observatories and a comprehensive outline of the courses of study, both graduate and undergraduate, and special lines of work that the students may take up The student may specialize along one of three lines, the nature of which is sufficiently indicated by the names,—Theoretical Astronomy and Celestial Mechanics; Astrophysics; Geodesy. During the first term of 1901 the total enrollment of students in astronomical courses was 92, and during the second term 119. Several special lines of work were carried on during 1901. Professor LEUSCHNER'S work upon the orbit of the faint asteroid discovered by the late Professor KEELER with the Crossley reflector has led to a new method of determining orbits from three observations. The work is to be published in the Lick Observatory Bulletins under the title of "A Short and General Method of Determining Orbits from Three Observations." Professor LEUSCHNER and Miss HOBE have also published in this same connection "Elements of Asteroid 1900 G. A. and Ephemeris for the Opposition of 1901–1902." Both of these papers were presented in the recent meeting of the Astronomical and Astrophysical Society of America. The new method has been applied by Mr. R. A. CURTISS and Mr. C. G. DALL to Comet *c* 1900, and is now being tested by application to the South Comet 1901 by Mrs. L. S. RICHARDSON and Mr. C. A. G. WEYMOUTH. Dr. TOWNLEY has been studying the light variations of *Nova Persei*, and a portion of the results obtained has already been printed in these *Publications*. Mr. J. D. MADDRILL, assistant in the observatory, has observed the magnitudes of *Nova Persei* and micrometer positions of asteroids. Dr. A. F. GILLIHAN, a special student, has also made micrometer observations of asteroids. Dr. R. T. CRAWFORD and Dr. F. E. ROSS are engaged for the Watson Trustees in computing the general perturbations of the Watson asteroids.

UNITED STATES COAST AND GEODETIC SURVEY OBSERVATORY.—This observatory, situated in the Presidio Reservation, San Francisco, and provided with a transit and a zenith-telescope, is used as a longitude base for the determination of new stations by telegraphic time-signals and for practice of observers. Captain AUG. F. ROGERS, Assistant in Coast Survey, and in charge of the observatory, writes, however, that no new determinations were made during 1901.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, JANUARY 25, 1902, AT 7:30 P.M.

President DOLBEER presided. A quorum was present. The minutes of the last meeting were approved.

A committee to nominate a list of eleven Directors and Committee on Publication, to be voted for at the annual meeting, to be held on March 29th, was appointed as follows: Messrs. D. S. RICHARDSON (Chairman), C. BURCKHALTER, J. COSTA, GEO. L. DILLMAN, HENRY J. CROCKER.

A committee to audit the accounts of the Treasurer, and to report at the annual meeting in March, was appointed as follows: Messrs. CHAS. S. CUSHING (Chairman), F. H. MCCONNELL, O. VON GELDERN.

Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE ROOMS OF THE SOCIETY, JANUARY 25, 1902, AT 8 O'CLOCK P. M.

President DOLBEER presided. The minutes of the last meeting were approved.

The following papers were presented:—

1. A Method for Determining the Screw Errors of a Zenith-Telescope, by Dr. FRANK SCHLESINGER.
2. Planetary Phenoma for March and April, 1902, by Professor MALCOLM MCNEILL.

In lieu of a scientific programme for this evening, a Special Meeting of the Society was called, to be held in Hearst Hall at Berkeley on Febuary 21, 1902, at 8 o'clock P. M., in conjunction with the University Exhibit of Astronomical Photographs taken at the Lick Observatory. It was announced that Professor W. W. CAMPBELL would address the meeting, giving an account of the meeting of the American Astronomical and Astrophysical Society, recently held in Washington.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. JOHN DOLBEER	*President*
Mr. S. D. TOWNLEY	*First Vice-President*
Miss R. O'HALLORAN	*Second Vice-President*
Mr. CHAS. S. CUSHING	*Third Vice-President*
Mr. C. D. PERRINE Mr. F. R. ZIEL	*Secretaries*
Mr. F. R. ZIEL	*Treasurer*

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Committee on Publication—Messrs. AITKEN, TOWNLEY, GALLOWAY.

Library Committee—Mr. TOWNLEY, Miss O'HALLORAN, Miss HOBE.

Committee on the Comet-Medal—Messrs. CAMPBELL (*ex-officio*), PIERSON, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. RUTHVEN W. PIKE.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. FRANCISCO RODRIGUEZ REY.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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ADDRESS OF THE RETIRING PRESIDENT OF THE SOCIETY, IN AWARDING THE BRUCE MEDAL TO PROFESSOR G. V. SCHIAPARELLI.

BY JOHN DOLBEER.*

The statutes for the bestowal of the Bruce Medal of the Astronomical Society of the Pacific direct that the President "in his address at the annual meeting of the Society in March is to announce the award and the reasons for making it." Complying with the statutes, I therefore take pleasure in announcing that by unanimous vote of the Board of Directors the Bruce Medal for the year 1902 was awarded to Professor GIOVANNI VIRGINIO SCHIAPARELLI, "for distinguished services to astronomy."

Every member of the Society will doubtless agree that no more worthy recipient of the medal could be found than Professor SCHIAPARELLI; and that it is especially appropriate that he should receive it at this time, when he has retired from the directorship of the observatory made famous throughout the world by his labors during the past forty years. For, unlike many, if not most, other medals founded to encourage astronomical work, the Bruce Medal is not bestowed as an award for some one particular research or discovery, however brilliant, but rather as the mark of our recognition of the fact that the medalist, by his long-continued and successful labors, has made himself one of the great leaders in the advance of the science of astronomy.

In the minds of most intelligent people outside of the ranks of the professional astronomers, the name of SCHIAPARELLI is probably most prominently associated with the planet *Mars;* and it is unquestionably true that his remarkable studies of the physical characteristics of that interesting planet form a strong claim to the high regard in which he is held by astronomers to-day. As one of our own members has said,—

---

* I am indebted to Professor R. G. AITKEN, of the Lick Observatory, for the collection and arrangement of the data contained in this address.

> "Professor SCHIAPARELLI has fixed the principal points of the planet's surface by a survey, and he has shown that they have remained constant since the time of MAEDLER and KAISER. By a series of drawings, he has constructed a most admirable map of the planet. On this map he has located the continents and the seas; and has traced a very large number of 'canals' (narrow, straight, dark lines), and shown that many of them appear at times to be doubled. The elegant nomenclature he has adopted in his map will be a pleasure to the classical scholar who may examine it. It is a scholar's review of antiquity. Professor SCHIAPARELLI has, however, been very chary of hypotheses. . . . Most of his writings have been concerned with the pure results of observation, and he has scrupulously refrained from generalizations."[*]

Another says:—

> "He has extended our knowledge of the planet enormously in nearly every line,—in reference to the polar caps, the so-called seas and continents, but especially in reference to the so-called canals, their appearance and disappearance, their doubling, etc. His entire work bears the impress of a scientific spirit *par excellence*. His technical results are comprised in a few papers, and a dozen octavo pages suffice for a masterly popular exposition of his general results. His brief papers contain at least the suggestion of all the theories recently exploited by popular writers, though he was not concerned with establishing a theory, but rather with ascertaining facts."[†]

But SCHIAPARELLI would rank with the foremost astronomers of our time if he had never published a paper on *Mars* or made a drawing of the planet. Not one of the three gold medals he holds, nor of the two Lalande prizes, was awarded to him for his studies on *Mars*. In fact, the gold medals were bestowed upon him before his work on *Mars* began.

Like AUWERS and GILL, our medalists in 1899 and 1900, SCHIAPARELLI'S early training specially fitted him for his future work. After six years spent in the University of Turin as student, especially of mathematics, engineering, and astronomy, and private tutor in mathematics, he received in 1856 a position as instructor in mathematics at the gymnasium in Turin. He held this position for only two months, however, having received orders from the government to continue his astronomical studies under ENCKE at Berlin. We find him, accordingly, applying himself to these studies for the two following years, taking courses as well in mathematics, physics, meteorology, terrestrial magnetism, etc., under such famous professors as ERMAN, WEIERSTRASS, POGGENDORFF, ARNDT, and OHM. To supplement these theoretical studies he next went to Pulkowa, and there spent a year in practical astronomical work under OTTO STRUVE and WINNECKE. He was now thoroughly prepared to enter upon his life work, and on the 30th of June, 1860, a young man of 25, he was appointed Second Astronomer at the Milan Observatory, then under the directorship of Professor CARLINI.

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[*] Professor EDW. S. HOLDEN. *The Forum*, November, 1892.

[†] Professor W. W. CAMPBELL. *Science*, August 21, 1896.

Forty years later, on June 30, 1900, when he resigned his position as Director of the Milan Observatory, the astronomers of Italy in testimony of their appreciation of his work, published a pamphlet entitled "All' Astronomo G. V. Schiaparelli, Omaggio 30 Giugno 1860–30 Giugno 1900," which recounts in detail the story of his scientific life and gives a complete list of his writings. In their address on this occasion, they call attention to his discovery a few months after assuming his duties at Milan, of a minor planet, *Hesperia*,—an event of more interest and significance in those days than at present,—and continue:—

> "With this discovery, made so soon after your entrance in the Observatory di Brera, you began to draw the attention of the astronomical world upon your name, which, having quickly achieved greater titles to fame, the history of astronomy records with high honor, recalling your observations and your studies upon the comet of 1862; your theory of meteors; your many and accurate observations of double stars; your observations and discoveries upon the planets *Mercury* and *Venus*, and particularly *Mars*; your researches in and reconstruction of the story of the astronomical thought of ancient times; your careful study of the motion of the pole of terrestrial rotation, etc.; while the history of meteorology and of terrestrial physics and of natural philosophy in general will record your many contributions as of the highest importance."

It is obviously impossible to mention even the titles of all these important papers, to say nothing of giving an adequate account of their contents. In addition to the brief reference already made to his well-known observations on *Mars*, we must confine ourselves to a very short account of the researches first mentioned in the passage just quoted; his study of the comet of 1862, his theory of meteors, and his observations of double stars.

That comets and meteors are very closely related,—so closely as to point conclusively to a common origin,—is now so generally believed by astronomers, that it is hard to realize that their relationship was not clearly established until less than forty years ago. Such is nevertheless the fact. Though KEPLER, HALLEY, and one or two others conceived the idea that meteors were of cosmical origin, the prevailing belief to the close of the eighteenth century was that they were due to "atmospheric perturbations, exhalations of sulphur, *ignes fatui*, and so forth," while such eminent men as LAPLACE and OLBERS thought it more probable that the meteors were composed of matter discharged from volcanoes on the Moon. Observational data concerning these phenomena began to accumulate in the early part of the nineteenth century, observation being greatly stimulated by the *Leonid* shower witnessed by HUMBOLDT in 1799, and by the celebrated display of 1833. After seeing the latter, and reading HUMBOLDT'S account of the former, OLMSTED was led to the conclusion that the appearance was due to the Earth's passage "through a storm, so to speak, of planetary bodies." He also first detected that the meteors of a shower *radiate* from a definite region of the sky—the radiant point.

In the period from 1833 to 1866 progress was rapid. Observers in Europe and America were zealous in collecting data, and NEWTON, ADAMS, ERMAN, KIRKWOOD, A. S. HERSCHEL, and many others were eagerly seeking the solution to the problems presented. NEWTON traced the recurrence of the *Leonid* shower, at intervals of about thirty-three years, back to the year 902; ADAMS determined with great accuracy the revolution period of the swarm from which the shower proceeds; and at about the same time SCHIAPARELLI concluded that the orbit of this swarm must be an elongated ellipse resembling the orbits of comets, rather than the nearly circular planetary orbits. The existence of many other radiants in the sky was established, and the study of the so-called sporadic meteors brought to light the diurnal and annual variations in their frequency and the relation of these variations to the orbital motion of the Earth and to the movement of the solar system in space.

Finally, SCHIAPARELLI, in 1866, computing an orbit for the August meteors, the *Perseids*, upon the assumption that their path was nearly parabolic, arrived at elements that were practically identical with those of TUTTLE'S comet of 1862, and thus completed the proof of the cosmical origin of meteors.

SCHIAPARELLI, therefore, was but one of many toilers in this field, and as in the case of nearly all great advances in scientific thought, his discovery had been foreshadowed and almost anticipated by some of his predecessors. But this does not in the least detract from the merits of his achievement. The actual discovery was his, and it is his distinction that by approaching the problem from a higher point of view and bringing to bear upon it a keener power of analysis, he was able to correlate the diverse phenomena and frame a comprehensive theory that would account for them all. So thoroughly did his writings on this subject, from 1863 to 1872, cover the ground, and so clearly did they point out the lines along which investigation should proceed, and the difficulties that remained to be overcome, that it may be said that the progress of the past thirty years in this important branch of astronomy has been mainly the elaboration of his ideas.

So far we have called attention only to SCHIAPARELLI'S researches within our own system,—for meteors and comets may be regarded as at least temporary members of the family of the Sun,—but no sketch of his career, however brief and inadequate, can omit mention of his notable contributions to our knowledge of the systems of the stars.

A student under OTTO STRUVE, a friend of Baron DEMBOWSKI, it is not strange that he should have been attracted to the study of double stars. Nor, remembering his habits of thoroughness, persevering industry, and attention to details, is it surprising that both the quality and the quantity of his work in this field entitle him to rank with the STRUVES, DEMBOWSKI, and BURNHAM, as one of the great double-star observers of the century. Nearly 12,000 observations of double stars are the result of his twenty-five years' labors with the 8-inch Merz equatorial, from February 7, 1875, to May, 1886, and with the 18-inch Repsold equatorial, from 1886 on. As his observing-list has always included the more important systems in reach of his instrument, the more interesting binary stars often being measured on as many as ten or fifteen nights in a year, it would be difficult to overestimate the value of this great mass of material to the double-star student of the present day; and its value will increase rather than diminish with the lapse of time.

Though he has now retired from the directorship of the Milan Observatory, I do not understand that Professor SCHIAPARELLI has given up his astronomical studies. In the larger leisure that he now enjoys, we trust that he may continue the researches that have made him famous, and may still further advance our knowledge of the worlds about us.

I hand the Bruce Medal to you, Mr. Secretary, to transmit to Professor SCHIAPARELLI with the assurance of the high esteem in which we all hold his name, and with the expression of our heartiest good wishes that he may long enjoy the honors to which his great services have entitled him.

March 29, 1902.

ASTRONOMICAL OBSERVATIONS IN 1901.

MADE BY TORVALD KÖHL, AT ODDER, DENMARK.

VARIABLE STARS.

Z Cygni.[*]

January	10:	*Z* a little > d.	September	2:	= b.
February	6:	= e.		12:	= c.
March	14:	utmost faint.		21:	id.
April	21:	invisible.		24:	id.
May	21:	id.	October	9:	= d.
June	29:	= c.		26:	< d.
August	19:	> b.		30:	< d. > e.
			November	1:	= e.
				9:	< e.
				30:	invisible.

S Ursæ majoris.[†]

January	10:	*S* invisible.	May	4:	> d. < c.
February	6:	= g.		21:	id.
	11:	id.	August	17:	invisible.
	15:	= f.		24:	id.
	24:	> f. < e.	September	2:	id.
March	9:	= e.		7:	< g.
	13:	id.		12:	id.
	20:	id.		19:	id.
	23:	id.	September	21:	id.
	29:	id.		24;	id.

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[*] *Vide* the sketch in the *Publications* A. S. P., No. 48, page 69.

Vide the sketch in the *Publications* A. S. P., No. 73, page 56.

October	9:	= f.
	11:	id.
	26:	a little < e.
	29:	= e.
	30:	id.
November	1:	id.
	3:	id.
	9:	id.
November	20:	> e. < d.
	22:	id.
	24:	almost = d.
	26:	id.
	30:	id.
December	2:	id.
	4:	= d.

*T Ursæ majoris.**

January	10:	*T* < c. > d.
February	6:	< e. > f.
	11:	a little > f.
	15:	= f.
	24:	= g.
March	9:	invisible.
	13:	id.
	20:	utmost faint.
	23:	id.
May	4:	invisible.
	21:	id.
August	17:	a little > a.
	24:	< a. > b.
September	2:	id.
	7:	id.
	12:	a little > b.
	19:	id.
September	21:	= b.
	24:	< b. > c.
October	9:	< c. > d.
	11:	= d.
	26:	= e.
	30:	id.
November	1:	id.
	3:	id.
	9:	< e. > f.
	20:	invisible.
	22:	id.
	24:	id.
	26:	id.
	30:	id.
December	2:	id.
	4:	id.

W Pegasi.

January	10:	*W* invisible.
February	6:	very faint.
August	17:	= e.
September	2:	< e.
	7:	a little > g. almost = f.
	21:	= h.
October	9:	very faint.
	29:	< h.
November	3:	id.
	9:	invisible
	30:	id
December	4:	id.

Nova Persei.

The star was discovered by THOMAS D. ANDERSON, in Edinburgh, on the 22d of February, in the forenoon, at half-past two o'clock, and was, before news about the discovery had reached our country, also seen by LAURSEN NORDVIG, in Maarslet, near

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* *Vide* the sketch in the *Publications* A. S. P., No. 22, page 63.

Aarhus, in Denmark. The following observations were made at Odder:—

Feb. 23, $6^h\ 30^m$ P.M. Brighter than *Capella*, $0^m.1$; blue white.
24, $5^h\ 30^m$ A.M. Brighter than *Vega*.
25. $7^h\ 30^m$ P.M. $0^m.80$.
28, $8^h\ 30^m$ P.M. $1^m.78$.
Mar. 4, 8^h P.M. A little $> \delta$ *Persei*.
9, 10^h P.M. $4^m.79$; deep red.

Mar. 13, 7^h30^mP.M. $\left\{ \begin{array}{l} < \epsilon\ Persei. \\ > \nu\ Persei. \end{array} \right.$
19, 8^h P.M. 5–6^m; the sky partly clouded.
20, $7^h\ 30^m$ P.M. A little $< \nu$ *Persei*.
22, 8^h P.M. 5^m; deep red.
23, 9^h P.M. $= \nu$ *Persei* $= 3^m.9$.
26, 9^h P.M. 5^m.
29, $9^h\ 15^m$ P.M. $5^m.36$.

After this date the sky was overclouded for twenty-three days.

Apr. 21, 10^h P.M. $= 30$ Fl. $= 5^m.41$.
23, $9^h\ 30^m$ P.M. 4^m, very bright; with visual spectroscope a red line was seen.
24, $9^h\ 30^m$ P.M. $= 30$ Fl.
25, 10^h P.M. $5^m.6$.
28, 11^h P.M. $5^m.5$. Red.
May 1, $10^h\ 30^m$ P.M. 6^m.
3, $9^h\ 30^m$ P.M. $5^m.4$.
4, $9^h\ 30^m$ P.M. 6^m.
10, 11^h P.M. id.
13, $11^h\ 30^m$ P.M. $= 32$ Fl. $= 5^m.1$.
21, $10^h\ 30^m$ P.M. $5^m.8$.
June 29, $11^h\ 50^m$ P.M. 6^m.
July 20, 1^h A.M. 6^m.
Aug. 17, 10^h P.M. $6^m.4$.
19, 10^h P.M. $6^m.6$.
24, 10^h P.M. $6^m.3$.
Sept. 2, 9^h P.M. id.
3, 9^h P.M. id.

Sept. 7, 9^h P.M. id.
12, 10^h P.M. $6^m.6$.
20. $11^h\ 30^m$ P. M. id.
21, 9^h P.M. $6^m.5$.
24, 9^h P.M. id.
Oct. 9, 9^h P.M. id.
11, $7^h\ 30^m$ P.M. $7^m.0$.
29, 8^h P.M. $6^m.8$.
31, 6^h P.M. id.
Nov. 1, 8^h P.M. id.
2, 8^h P.M. id.
3, 8^h P.M. id.
9, 8^h P.M. id.
20, $6^h\ 30^m$ P.M. $7^m.2$.
22, 9^h P.M. $7^m.5$.
23, 11^h P.M. $7^m.2$.
26, 6^h P.M. id.
30, 6^h P.M. $7^m.0$.
Dec. 4, 6^h P.M. $7^m.5$.
6, $6^h\ 30^m$ P.M. $7^m.2$.
8, 9^h P.M. id.

SHOOTING STARS.

Simultaneous observations on meteors were made from several stations in Denmark and Sweden. From the northwestern rampart of the ancient Uranienborg, where TYCHO BRAHE made his admirable observations, more than three hundred years ago, I watched the shooting-stars on the 9th, 10th, and 11th of August, and the paths of one hundred such meteors were drawn upon the map. From all the stations 417 meteors were observed.

FIREBALLS.

In the past year seventeen fireballs have been seen from stations in Denmark.

No.	Time. h m	Beginning.	End.	Mag.	Station.	Note.
1	Jan. 17, 4 16 P. M.	WNW. 45° alt.	NNW.	1	Copenhagen...	Exploded into three or four parts. Seen from several stations.
2	21, 10 28	160° + 50°	177° + 24°	1	Hellerup......	White meteor, lasting 4 seconds.
3	22, 12 32 A. M.	96° — 7°	115° — 20°	♀	Præstö........	Very slow; duration 5 seconds; was at first of the third magnitude.
4	29, 8 30 P. M.	......	E.	*	Lidsted (Bornholm).	Large meteor, with a bright train; whistling in the air; after three minutes three detonations were heard.
5	Feb. 12, 6 10	......	Below *Sirius.*	*	Hareskov.....	Red; large train.
6	24, 11 50	......	......	*	Kolding.......	Explosion; the pieces of various colors.
7	28, 6 10	*Cassiopeia.*	30° + 40°	1·4☾	Copenhagen...	Yellow; train.
8	April 23, 10 17	279° + 42°	320° + 48°	1·5☾	Copenhagen...	
9	Aug. 14. 9 50	......	......	*	Lyngby.......	
10	15, 10 15	......	......	*	Hovedgaard...	Explosion.
11	18, 10 15	270° + 82°	202° + 27°	*	Olstrup	Train, lasting 5 seconds.
12	24, 10 43	307° + 13°	315° — 2°	♀	Odder	Orange; duration 4 seconds.
13	Sept. 8, 10 16	32.5° + 32°	20° + 20°	♀	Copenhagen...	Train, lasting 4·5 seconds.
14	Oct. 6, 10 42	158° + 56°	118° + 32°	*	Maarslet	Red; very slow; duration of the movement 15 seconds. Also seen at Odense.
15	Nov 15, 12 30 A. M.	*Leo-Camelopardalus.*	*Cassiopeia-Pegasus.*	*	Veile	Train for 30 seconds.
16	16, 10 25 P. M.	57° + 15°	76° — 2°	♀	Veile	Red; explosion; duration 6 seconds; was at first of the third magnitude. Also seen at Copenhagen.
17	Dec. 9, 9 0	E.	W.	*	Strö	Horizontal path; slow.

PLANETARY PHENOMENA FOR MAY AND JUNE, 1902.

By Malcolm McNeill.

May.

There will be a partial eclipse of the Sun on May 7th. It is rather larger than the one on April 8th, the maximum obscuration being about five sixths of the Sun's diameter, but it is visible only in the South Pacific. New Zealand is about the only large land-mass in its path.

Mercury is an evening star throughout the month, having passed superior conjunction on April 28th. At the beginning of May it is too near the Sun to be seen; but by the end of the first week it is far enough away to show in the evening twilight, and for the last ten days of the month it remains above the horizon nearly two hours after sunset. It reaches greatest east elongation (23°) on May 28th. This is rather smaller than the west elongation in March, but is better than the east elongation in February. It gives the best opportunity of the year for seeing the planet.

Venus is still morning star, and throughout the month rises about two hours before sunrise. It passed its greatest west elongation in April, and the distance between the planet and the Sun is beginning to diminish, but the rate is as yet very slow, less than 1° for the month.

Venus will be perceptibly less bright than it was during April, but no other planet will compare with it.

Mars is drawing a little farther away from the Sun, but is still too near for naked-eye observation. By the end of the month it rises a little less than an hour before sunrise. It reaches its maximum distance from the Earth on May 20th. It is then 226,000,000 of miles away from us, about 8,000,000 less than its average maximum.

Jupiter rises earlier than during April — before midnight by the end of May; so it is getting into good position for early-morning observation. It is still in the constellation *Capricorn*, and moving eastward, but at a much diminished rate, only 2° during the month.

Saturn rises about an hour earlier than *Jupiter*, and by the end of the month is far enough above the horizon to be seen with the naked eye at midnight. It ceases its eastward motion among the stars on May 8th and begins to retrograde, but very slowly. Naked-eye observations will show very little change in its position during the month.

Uranus rises early enough for late evening observations toward the close of the month. It is in *Ophiuchus* between *Sagittarius* and *Scorpio*, and moves about 1° westward during the month.

Neptune is still in the evening sky, but sets earlier. It is in conjunction with *Mercury*, the latter passing about 3° north, on May 29th.

JUNE.

The Sun reaches its maximum declination at the summer solstice June 22d, 1 A.M., Pacific time.

Mercury is still an evening star, and remains in good position for observation until nearly the middle of the month. This prolonged period of visibility — over a month — is due partly to the fact that it is in aphelion on June 17th, and hence its elongation from the Sun is greater than the average. After the middle of the month it rapidly approaches the Sun and reaches inferior conjunction on June 23d.

Venus still keeps up its relative position with respect to the Sun, and the interval between the rising of the planet and that of the Sun increases about a quarter of an hour, although the apparent distance diminishes about 2°. The reason for the increased interval is, that *Venus* is still moving northward, while the Sun begins to move southward at the solstice, on June 22d, this causing a greater change in relative time of rising than the change in the opposite direction caused by diminution of distance.

Mars is drawing a little farther away from the Sun, and by the end of the month rises about an hour and a half before sunrise; but it will not be an easy object, on account of its faintness.

At the end of June *Jupiter* will rise before 10 P.M.. It ceases its eastward motion and begins to move westward on June 6th. By the end of the month it will have moved about 1°, and will be in about the same position it held in the middle of May, in the eastern part of *Capricorn.*

Saturn is in the western part of the same constellation, and is also moving westward, not quite 2° during the month. It can now be made out easily, before midnight or earlier, toward the end of the month.

Uranus is above the horizon practically the whole night, and comes to opposition on June 10th. It moves westward about 1°.

At the beginning of the month it is a little less than 2° north of the third-magnitude star *θ Ophiuchi.*

Neptune is in conjunction with the Sun on June 23d, and changes from an evening to a morning star.

MAY–JUNE, 1902.

PHASES OF THE MOON, P. S. T.

New Moon . . .	May 7,	2^h 45^m	P.M.
First Quarter . . .	May 14,	5 40	A.M.
Full Moon . . .	May 22,	2 46	
Last Quarter . . .	May 30,	4 00	
New Moon . . .	June 5,	10 11	P.M.
First Quarter . . .	June 12,	3 54	
Full Moon . . .	June 20,	6 17	
Last Quarter . .	June 28,	1 52	

THE SUN.

1902.		R. A.	Declination	Rises.	Transits.	Sets.
May	1,	2^h 31^m	+14°52′	5^h 5^m A.M.	11^h 57^m A.M.	6^h 49^m P.M.
	11,	3 10	+17 42	4 55	11 56	6 57
	21,	3 49	+20 03	4 45	11 56	7 7
	31,	4 30	+21 49	4 39	11 57	7 15
June	10,	5 11	+22 58	4 36	11 59	7 22
	20,	5 52	+23 26	4 36	12 1 P.M.	7 26
	30,	6 34	+23 13	4 39	12 3	7 27

MERCURY.

1902.		R. A.	Declination	Rises.	Transits.	Sets.
May	1,	2 42	+15 56	5 12 A.M.	12 8 P.M.	7 4 P.M.
	11,	4 6	+22 40	5 31	12 53	8 15
	21,	5 19	+25 27	5 52	1 26	9 00
	31,	6 8	+24 57	6 4	1 36	9 8
June	10,	6 27	+22 39	5 54	1 15	8 36
	20,	6 14	+20 03	5 12	12 23	7 34
	30,	5 52	+18 44	4 15	11 21 A.M.	6 27

VENUS.

1902.		R. A.	Declination	Rises.	Transits.	Sets.
May	1,	23 39	+ 2 56	3 15 A.M.	9 5 A.M.	2 55 P.M.
	11,	0 18	+ 0 29	3 4	9 5	3 6
	21,	0 58	+ 4 13	2 52	9 6	3 20
	31,	1 40	+ 8 3	2 41	9 8	3 35
June	10,	2 23	+11 48	2 31	9 11	3 51
	20,	3 8	+15 16	2 23	9 16	4 9
	30,	3 54	+18 16	2 20	9 24	4 28

MARS.

1902.		R. A.	Declination	Rises.	Transits.	Sets.
May	1,	2 4	+12 10	4 49 A.M.	11 30 A.M.	6 11 P.M.
	11,	2 32	+14 41	4 28	11 19	6 10
	21,	3 1	+16 58	4 10	11 9	6 8
	31,	3 31	+18 58	3 51	10 58	6 5
June	10,	4 0	+20 39	3 36	10 49	6 2
	20,	4 30	+21 59	3 20	10 39	5 58
	30,	5 0	+22 59	3 6	10 29	5 52

JUPITER.

May	1,	21 12	— 16 46	1 37 A.M.	6 39 A.M.	11 41 A.M.
June	1,	21 20	— 16 19	11 42 P.M.	4 45	9 48
July	1,	21 16	— 16 43	9 41	2 43	7 45

SATURN.

May	1,	19 59	— 20 35	12 39 A.M.	5 26 A.M.	10 13 A.M.
June	1,	19 58	— 20 43	10 37 P.M.	3 23	8 9
July	1,	19 51	— 21 4	8 33	1 18	6 3

URANUS.

May	1,	17 20	— 23 12	10 7 P.M.	2 43 A.M.	7 19 A.M.
June	1,	17 15	— 23 8	8 4	12 41	5 18
July	1,	17 10	— 23 2	5 56	10 33 P.M.	3 10

NEPTUNE.

May	1,	5 57	+ 22 20	8 3 A.M.	3 23 P.M.	10 43 P.M.
June	1,	6 2	+ 22 21	6 4	1 25	8 46
July	1,	6 6	+ 22 21	4 11	11 32 A.M.	6 53

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off left-hand limb as seen in an inverting telescope.)

I,	D,	May	7,	4^h 56^m A.M.
II,	D,		7,	11 55 P.M.
I,	D,		8,	11 24 P.M.
II,	D,		15,	2 29 A.M.
I,	D,		16,	1 19 A.M.
I,	D,		23,	3 12 A.M.
I,	D,		24,	9 41 P.M.
I,	D,		31,	11 35 P.M.
III,	D,	June	1,	9^h 19^m P.M.
III,	R,		2,	12 50 A.M.
IV,	D,		6,	11 26 P.M.
IV,	R,		7,	3 59 A.M.
I,	R,		8,	1 29 A.M.
II,	D,		8,	11 27 P.M.
III,	D,		9,	1 19 A.M.
III,	R,		9,	4 50 A.M.
I,	D,		15,	3 23 A.M.
II,	D,		16,	2 1 A.M.
I,	D,		16,	9 12 P.M.
II,	D,		23,	4 35 A.M.
IV,	R,		23,	10 7 P.M.
I,	D,		23,	11 46 P.M.

APPROXIMATE ELEMENTS OF THE ORBITS OF THE COMETS FROM 1896 TO 1901.

By W. J. HUSSEY.

In number 50 of these *Publications* (June, 1896), a number of tables compiled by the late Professor WINLOCK are printed, giving the approximate elements of all computed orbits of comets from B. C. 372 to A. D. 1896. The following table of the approximate elements of the comets which have appeared during the years 1896 to 1901, inclusive, is intended as a continuation of Professor WINLOCK's first table, and it is arranged in the same manner:—

APPROXIMATE ELEMENTS OF THE ORBITS OF THE COMETS FROM 1896 TO 1902.

Number.	T			ω	☊	i	q	a	P	e	Discoverer.
420......	1896	I	Jan. 31.8	358°.5	254°.8	155°.9	0.588	....	....	....	PERRINE.
421 F....	1896	II	Mar. 19.3	201 .2	209 .8	11 .3	1.738	3.854	$7^{y}.57$	0.549	
422......	1896	III	April 17.6	1 .7	178 .3	55 .6	0.566	....	....	....	SWIFT.
423......	1896	IV	July 10.9	41 .0	151 .0	88 .4	1.142	....	....	....	SPERRA.
424......	1896	V	Oct. 26.0	139 .5	192 .1	11 .6	1.482	3.500	6 .55	0.657	GIACOBINI.
425 Bro..	1896	VI	Nov. 4.2	343 .8	18 .0	6 .1	1.959	3.684	7 .072	0.469	
426......	1896	VII	Nov. 24.6	163 .9	246 .6	13 .7	1.110	3.462	6 .441	0.677	PERRINE.
427......	1897	I	Feb. 8.1	172 .3	86 .3	146 .1	1.062	....	....	....	PERRINE.
428 d'A..	1897	II	May 27.3	173 .0	146 .3	15 .7	1.324	3.551	6 .691	0.627	
429......	1897	III	Dec. 8.8	66 .1	32 .1	69 .6	1.356	....	....	....	PERRINE.
430......	1898	I	Mar. 17.4	145 .1	262 .5	72 .5	1.099	....	....	....	PERRINE.
431 W...	1898	II	Mar. 20.4	173 .3	100 .9	17 .0	0.924	3.235	5 .818	0.725	
432 E. ..	1898	III	May 27.8	184 .0	334 .8	12 .9	0.341	2.218	3 .303	0.846	
433 Wo..	1898	IV	July 4.6	172 .9	206 .5	25 .2	1.604	3.597	6 .821	0.557	
434......	1898	V	July 25.5	22 .4	278 .3	166 .9	1.501	....	....	....	GIACOBINI.
435......	1898	VI	Aug. 16.2	205 .6	259 .1	70 .0	0.627	....	....	....	PERRINE.
436......	1898	VII	Sept. 14.1	233 .3	74 .0	69 .9	1.702	....	....	....	CODDINGTON.
437......	1898	VIII	Sept. 20.1	4 .6	91 .8	22 .5	2.269	....	....	....	CHASE.
438. ...	1898	IX	Oct. 20.5	162 .4	34 .9	28 .9	0.420	....	....	....	PERRINE.
439......	1898	X	Nov. 23.2	123 .6	96 .3	140 .4	0.756	....	....	....	BROOKS.
440......	1899	I	April 13.0	9 .0	25 .1	146 .3	0.325	....	....	....	SWIFT.
441 Ho..	1899	II	April 27.7	14 .1	331 .7	20 .8	2.128	3.615	6 .90	0.411	
442 Tu. .	1899	III	May 4.5	206 .7	269 .9	54 .5	1.024	5.724	13 .76	0.822	
443 T2 .	1899	IV	July 28.5	185 .6	121 .0	12 .6	1.389	3.033	5 .281	0.542	
444......	1899	V	Sept. 15.0	10 .9	272 .2	76 .9	1.785	....	....	....	GIACOBINI.
445......	1900	I	April 29.1	24 .6	40 .4	146 .4	1.329	....	....	....	GIACOBINI.
446......	1900	II	Aug. 3.2	12 .4	328 .0	62 .5	1.015	....	....	....	BROOKS-BORRELLY.
447......	1900	III	Nov. 28.3	171 .5	196 .5	29 .9	0.934	3.617	6 .66	0.742	GIACOBINI.
448......	1901	I	April 24.3	203 .0	109 .6	131 .1	0.245	....	....	....	(Great Comet).
449 E. ..	1901	II	Sept. 15.3	184 .0	334 .8	12 .9	0.341	2.219	3 .303	0.846	

The abbreviations used in the first column to designate the periodic comets on their return to perihelion are as follows:

d'A.	= D'ARREST's comet.	F.	= FAYE's comet.	Tu.	= TUTTLE's comet.
Bro.	= BROOK's comet.	Ho.	= HOLME's comet.	W.	= WINNECKE's comet.
E.	= ENCKE's comet.	T2	= TEMPEL's second periodic comet.	Wo.	= WOLF's comet.

THE STARS: A STUDY OF THE UNIVERSE. BY PROFESSOR SIMON NEWCOMB.—A REVIEW.

By W. W. CAMPBELL.

Centuries ago the starlike points that we see in the sky were classified as planets (wanderers) and fixed stars. Modern observations have shown that the term fixed is a misnomer: that the stars are in reality moving more rapidly, on the average, than the planets. Professor NEWCOMB has appropriately chosen the simple title of "The Stars" for his most interesting and suggestive book.

The study of the stars resolves itself into the consideration of two great subjects,—perhaps the greatest subjects in the whole realm of pure knowledge, viz.:—

I. *The Structure of the Universe.*
II. *The History of the Universe.*

All the researches of the astronomers of the past and present are but minor contributions to the solution of these main problems. Professor NEWCOMB'S book touches lightly upon the second subject — indeed the present-day data are entirely too meager to warrant its serious consideration;— but he has entered boldly upon a determination of the Structure of the Universe. He has written excellent chapters on the cataloguing, the photometry, the motions, the parallaxes of the stars; and the seven concluding chapters, combining the results in the various departments of investigation in an effort to solve the main problem, are of surpassing interest. The scope of the book will be realized best from the following extract (Chapter XIV): —

> "First, we may inquire as to the extent of the universe of stars. Are the latter scattered through infinite space, so that those we see are merely that portion of an infinite collection which happens to be within reach of our telescopes, or are all the stars contained within a certain limited space? In the latter case, have our telescopes yet penetrated to the boundary in any direction? In other words, as, by the aid of increasing telescopic power, we see fainter and fainter stars, are those fainter stars at greater distances than those before known, or are they smaller stars, contained within the same limits as those we already know? Otherwise stated, do we see stars on the boundary of the universe?
>
> "Secondly, granting the universe to be finite, what is the arrangement of the stars in space? Especially, what is the relation of the galaxy to

the other stars? In what sense, if any, can the stars be said to form a permanent system? Do the stars which form the Milky Way belong to a different system from the other stars, or are the latter a part of one universal system.

"Thirdly, what is the duration of the universe in time? Is it fitted to last forever in its present form, or does it contain within itself the seeds of dissolution? Must it, in the course of time, in we know not how many millions of ages, be transformed into something very different from what it now is? This question is intimately associated with the question whether the stars form a system. If they do, we may suppose that system to be permanent in its general features; if not, we must look further for our conclusion."

In considering these questions, NEWCOMB has taken the view of modern science that "no answer is valid unless based on careful observation." The facts of observation described in the preceding chapters are made to bear with excellent judgment and great skill. The valuable but more limited investigations by SEELIGER, KAPTEYN, SCHIAPARELLI, and others are utilized — due credit being given. It is impossible to describe in a short article the methods of solution followed; the hundred pages of the book devoted to their consideration cannot be condensed, but must be read as a whole.

A few of the many conclusions arrived at are as follows:—

1. If we consider as of unit volume the sphere whose radius is 200,000 times the Earth's distance from the Sun, we may say that there is one star on the average for eight units of volume.

2. That collection of stars which we call the universe is limited in extent. . . . This does not preclude the possibility that far outside of *our* universe there may be other collections of stars of which we know nothing.

3. The boundary of our universe is probably somewhat indefinite and irregular. As we approach it the stars may thin out gradually. The parallax at the boundary is probably no where greater than 0".001, and may be much less. The time required for light to pass over the corresponding interval is more than 3,000 years.

4. The universe extends further around the girdle of the Milky Way than towards the poles of that girdle.

5. The total number of the stars is to be counted by the hundreds of millions.

The work, as a whole, contains a vast amount of information, stated philosophically and in a manner adapted to the needs of the working astronome., as well as to the comprehension of the general reader. The author's greater experience along mathematical lines is the satisfactory explanation for a weakness here and there in the astrophysical chapters. As a case in point, the latter part of page 188, on the spectra of the nebulæ, should be rewritten for subsequent editions. The strong chapters are those in which the author has used the statistical method, and it is fortunate that his ripe judgment was brought to bear upon these difficult problems.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

OBSERVATIONS OF THE SATELLITES OF *SATURN*.

This series of observations — viz., those given in the *Bulletin* of the Lick Observatory, No. 17 — includes my measurements of the relative positions of all the satellites of *Saturn* except *Iapetus*, the one most distant from the planet; also, measurements of the directions and distances of *Enceladus*, *Tethys*, *Dione*, *Rhea*, *Titan*, and *Hyperion* from the center of the planet. The latter measurements were difficult to make, owing to *Saturn's* large size and the unsymmetrical form of the visible portion of the planet's disc. During the years in which these observations were made the rings had about their maximum opening, and a considerable portion of the planet's southern hemisphere was concealed beneath them. In 1898 and in 1901 its south polar region was invisible. This made it impossible to obtain complete sets of measures of the rectangular coordinates of the satellites from the preceding and following limbs and from the poles of the planet, and such measures were therefore not attempted. The position-angles and distances were obtained by bisecting the disc of the planet with the micrometer-wire. My judgment as to the position of the center of the disc was formed partly by considering the shape and size of the visible portion of the disc and what would have to be added to it to render its outline truly elliptical, and partly from the configuration formed by the inner edge of the ring and the outline of the planet.

Measurements of the relative positions of two satellites can be made with comparative ease, and the results so obtained are less subject to large systematic and accidental errors than those just described. It appears quite certain that improvement in the theories of the motions of the satellites of *Saturn* will be made largely by means of the observations of the relative positions of the satellites themselves. On this account, in the present series, it has been the first object to secure as many measures of this kind as possible. During the past year the only satellites connected directly with the planet were the remote ones, *Titan* and *Hyperion*. W. J. HUSSEY.

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* Lick Astronomical Department of the University of California.

RESIDUALS FOR OBSERVATIONS OF THE SATELLITES OF *URANUS* AND *NEPTUNE*.

I have compared my observations of the satellites of *Uranus*, made in 1897 and 1898, with places computed by means of Professor NEWCOMB'S tables of their motions, given in Appendix I of the Washington Observations for 1873. The average values of the residuals, in the sense O–C, are as follows:—

Ariel	+ 1°.5	— 0″.19
Umbriel . .	+ 2 .0	+ 0 .12
Titania . . .	+ 1 .3	— 0 .05
Oberon . . .	+ 0 .6	— 0 .17

These residuals, like those recently published by Professor AITKEN, show that the satellites are slightly in advance of their predicted places. The differences, however, between the observed and computed position-angles are very small, and would vanish if the adopted mean motions were very slightly increased.

I have also compared my observations of the satellite of *Neptune* with places computed by means of Dr. HERMANN STRUVE'S elements. The average values are as follows:—

Satellite of *Neptune* . . + 0°.2 + 0″.33

These elements represent the observation on angle with great exactness, all the residuals being of the same order of magnitude as the probable errors of observation. W. J. HUSSEY.

THE PRESSURE OF HEAT AND LIGHT RADIATION.

At the meeting of the American Association for the Advancement of Science, held in Denver in August, 1901, a paper* by Professor E. F. NICHOLS and Mr. G. F. HULL, of Dartmouth College, was read, giving an account of their experiments in determining the pressure of heat and light. A paper on the same subject was read by Professor NICHOLS at the meeting of the Astronomical and Astrophysical Society of America at Washington, in December, 1901.

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* Published in the *Physical Review*, Vol. XIII, No. 5, November, 1901.

The experimental proof that such a pressure is exerted by light is of great importance to astronomy. Such a property of light offers a reasonable explanation of several very perplexing phenomena, and will doubtless be found to assist materially in the solution of others.

Pressure of this character was first suggested by MAXWELL in dealing theoretically with the stresses in an electromagnetic field. BARTOLI later announced that a similar pressure was essential to one of the fundamental laws of thermodynamics. He failed, however, to detect such an effect experimentally, from the difficulty of isolating the phenomenon. Other investigators have discussed the problem theoretically, and especially the applications of such a pressure to the solution of various observed phenomena, in which many interesting results have been reached. The experimental solution had failed, however, owing to the action of gases surrounding the body experimented upon which it was found impossible to eliminate. The molecules of such gas exerted pressure which completely masked the force which it was sought to measure.

Following are the considerations acted upon by NICHOLS and HULL in their successful attempt to isolate this force :—

"1. The surfaces which receive the radiation, the pressure of which is to be measured, should be as perfect reflectors as possible. This will reduce the gas-action by making the rise of temperature due to absorption small, while the radiation-pressure will be increased; the theory requiring that a beam, totally reflected, exert twice the pressure of an equal beam completely absorbed.

"2. By studying the action of a beam of constant intensity upon the same surface surrounded by air at different pressures, certain pressures may be found where the gas-action is smaller than at others.

"3. The apparatus—some sort of torsion-balance—should carry two surfaces systematically placed with reference to the rotation-axis, and the surfaces on the two arms should be as nearly equal as possible in every respect save one—the forces due to radiation and gas-action should have the same sign on one side and opposite signs on the other. In this way a mean of the resultant forces on the two sides should be, in part at least, free from gas-action.

"4. Radiation-pressure, from its nature, must reach its maximum value instantly, while observation has shown that the gas-action begins at zero and increases with length of exposure, rising rapidly at first, then more slowly to its maximum effect, which, in most of the cases observed, was not reached until the exposure had lasted from 2½ to 3 minutes. For large gas-pressures, an even longer exposure was necessary to reach stationary conditions. The gas-action may be thus still further reduced by a ballistic or semi-ballistic method of measurement."

The apparatus for the observation of these pressures consisted of a delicate and especially arranged torsion-balance carrying two small glass vanes, one on either side of the rotation axis. Each of the vanes had one of its sides silvered and highly polished. These vanes were so hung that the glass face of one and the silvered face of the other were turned to the light. A beam of light from an arc-lamp was allowed to fall in turn upon each vane, and the deflection of the balance read by a telescope in which was observed the image of a scale reflected in a small mirror attached to the balance. At the same time that the deflection of the vanes was observed the intensity of the beam of light was observed by means of a thermopile and galvanometer. The balance was placed in a bell-jar which was connected with an air-pump and a large part of the air exhausted. The first observations consisted in allowing the beam of light to fall upon each vane for a sufficient time to allow the conditions of gas-pressure and radiation-pressure to become stationary, as indicated by the balance coming to rest. This was done for each vane in succession, and observations made at eight gas-pressures between 0.06^{mm} and 96^{mm} of mercury. The results, however, showed such complicated gas-actions at certain pressures that no certain conclusions could be drawn as to the existence of a constant force such as that sought. A comparison of these observations with the more accurate ones obtained later by means of short exposures, showed that in the first series the gas-action varied from one tenth to 6 or 7 times the actual pressure of light.

In the method of short exposures the light was allowed to fall on the vane for 6 seconds, which was one fourth of the period of vibration of the balance and the resulting deflection computed from the known laws of such a system. In this way very definite results were secured, as shown in the following table :—

p	*d*
96.3	19.7
67.7	21.0
37.9	21.6
36.5	22.1
33.4	21.1
1.2	20.9
0.13	26.8
0.06	23.2
Mean,	22.5

The column *p* gives the gas-pressure in the bell-jar in millimeters of mercury, and column *d* the permanent deflection in millimeters due to radiation-pressure. From the known constant of the torsion-balance this deflection gives 1.05×10^{-4} dynes as the radiation pressure.

By means of a bolometer constructed for the purpose, the energy of the radiation causing these deflections was measured, and it was found to correspond to a pressure of 1.34×10^{-4} dynes. The observations, therefore, show 78 per cent. of the total pressure of the beam indicated by the bolometer measurements. Some of the sources of error in the bolometer results which would tend to bring the observations into better agreement are indicated by the investigators.

According to a letter from Professor NICHOLS, later observations with improved apparatus have reduced the difference between the pressure of the radiation as measured directly and that indicated from theory, through measurements of the beam of light with the bolometer, to 5 per cent. This difference is extremely small, considering the difficult nature of the observations.

Ten years ago LEBEDEW explained the anomalous appearances exhibited by the tails of comets by assuming such a pressure of light to act in opposition to the Sun's attractive force. Such a theory accounts for the different types of cometary tails by supposing that the individual particles composing them are of different sizes.

As the velocity due to gravity depends upon the *mass* of the particle, while the velocity due to radiation-pressure depends upon the *surface*, the resultant will be different for particles of different sizes. Comparatively large particles will obey the force of gravity, while in the case of the smaller ones the radiation-pressure will be most effective and will cause them to move in opposition to gravity. The smallest rapidly moving particles would thus compose the long, straight tails of comets, while the short, curved tails would be composed of larger particles. Particles still larger would be acted upon sufficiently by gravity to cause them to move towards the Sun.

This explanation of cometary phenomena has recently been revived by ARRHENIUS, and the theory of radiation-pressures extended to cover a number of other phenomena — e. g., the Zodiacal Light, Gegenschein, Aurora Borealis, etc.

This property of radiation must be nearly as wide-spread as gravity itself, and will have to be considered in all theories relating to finely divided matter at least.

It is perhaps not too much to expect that ere long we shall know much more of this new property of light and heat, especially its relations to different wave-lengths.

C. D. PERRINE.

MT. HAMILTON, CALIFORNIA, March 19, 1902.

ORIGIN OF A DISTURBED REGION OBSERVED IN THE CORONA OF 1901, MAY 17–18TH.

One of the most conspicuous features of the recent eclipse was an area of disturbance in the Corona off the east limb, to which I called attention in my first reports.*

The disturbance had the form of an inverted cone, with its apex on or very near the Sun's limb. It had the appearance of being composed of cloudlike masses of matter, arranged in such a manner as we should expect if it were the result of an eruption on the Sun's surface. In fact, the appearance alone very strongly suggests such an origin. Close to the apex of this region is a long, slender prominence, almost tangential to the limb, which seems to have had its origin at the same point as the coronal disturbance.

No spots or unusual faculæ had been observed just previous to the eclipse, nor were any observations or photographs available until recently with which to investigate the question of origin. Through the kindness of the Astronomer Royal, Royal Observatory, Greenwich, the Lick Observatory has been supplied with copies on glass of the negatives of the Sun taken at Dehra Dûn, India, on May 17, 18, 19, 20, 21, 22, 26, and 28, 1901. These photographs are on a scale of 7½ inches to the solar diameter and furnish the requisite data.

The photographs of May 17th and 18th show no spots or other evidences of unusual activity on any part of the Sun's disc. On the photograph of May 19th, however, is a spot of medium size which has just appeared around the east limb. Owing to foreshortening, the spot, on this date, is little more than a line ½′ in length, surrounded by faculæ. On the 20th it is ¾′ in length (north and south), and is followed at a distance of ½′ by several small spots, forming a close group.

The principal spot is compact, with well-defined umbra and penumbra, and shows no unusual changes during the interval covered by the photographs. The group of small spots following, however, shows considerable growth.

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* Lick Observatory *Bulletin*, No. 9. *Publications A. S. P.*, Vol. XIII, p. 196.

The following coordinates of the principal spot have been deduced from the plates of May 19th and 28th, the longitudes being measured from the center of the disc:—

	Greenwich Civil Time.	Longitude.	Latitude.
1901 May 19,	3h 30m 37s	80°.7 East	+ 9°.0
28,	7 29 37	46 .7 West	+ 9 .0

From these positions, the spot was found to occupy the following position at the time of the eclipse in Padang:—

	Greenwich Mean Time.	Longitude.	Latitude.
1901 May 17,	17h 40m 37s	93°.8 East	+ 9°.0

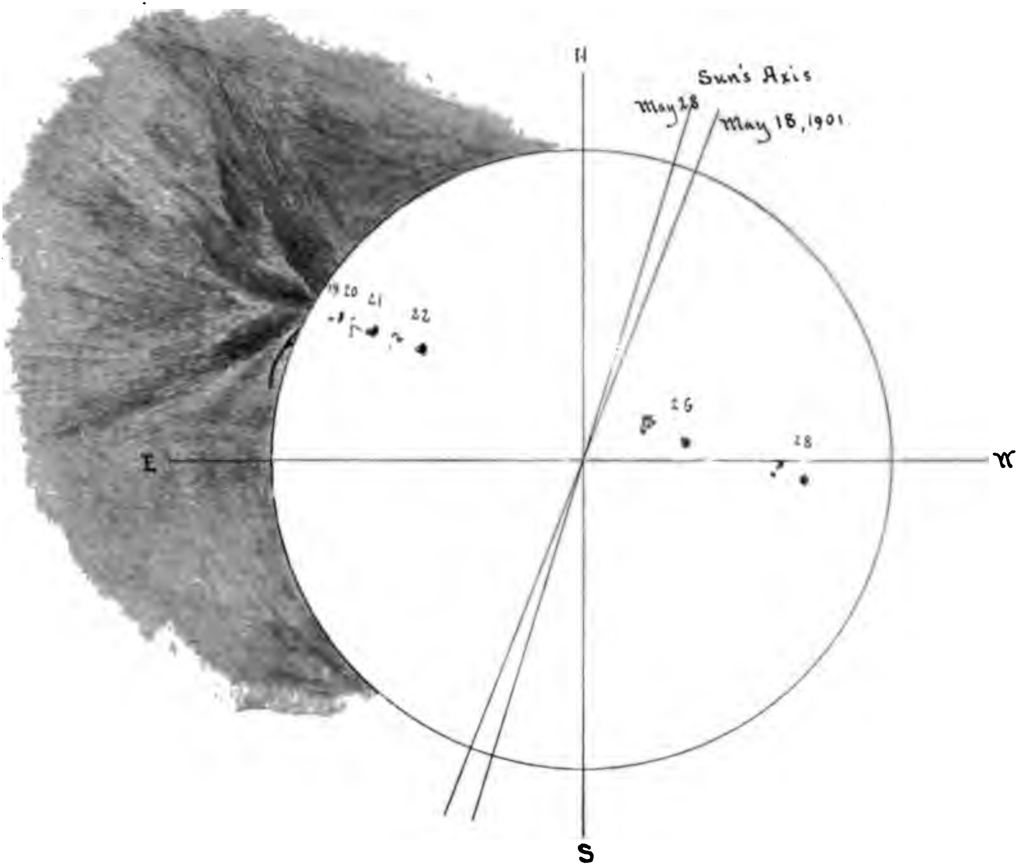
Thus the spot was on the opposite side of the Sun at the time of the eclipse and within 4° of the limb. Following are the position-angles of the spot as projected on the limb, and of the apex of the disturbed area in the corona observed on the eclipse negatives.

	Position Angle.
Sun-spot	60°.2
Apex of coronal disturbance	60 .0

During the period of eleven days covered by the photographs, only this one group of spots was visible. In this time almost the entire solar surface was under observation.

From the above position-angles it is seen that this group of sun-spots occupied the same line of sight as the apex of the disturbed coronal region. The accompanying illustration makes this clear. The spots have been copied from the Dehra Dûn photographs, and the principal masses of the coronal disturbance were sketched in to the same scale, from the eclipse negatives taken with the 40-foot camera.

We have no means of determining the position *in the line of sight* of the apex of the coronal disturbance other than that afforded by the angle of the cone-shaped area. This indicates an origin near the limb. It can, therefore, hardly be doubted that this disturbed region in the corona was in reality immediately above the group of sun-spots and faculæ, and that it had its origin in the same disturbance of the Sun's surface. The long, threadlike prominence alluded to seems likewise to have originated in the same group of spots and faculæ.


N
Sun's Axis
May 28
May 18, 1901
19
20
21
22
26
28
E
W
S

These observations indicate very strongly the intimate connection of all solar phenomena. Sun-spots, faculæ, prominences, and corona all seem, in this instance at least, to have had a common origin.

The undoubted connection of this coronal disturbance with the group of spots and faculæ on the surface, and its appearance so strongly suggested great activity, that a set of measurements was made of some of the best-defined masses to see if motion could be detected. The greatest interval of time available between photographs of the corona suitable for this purpose was but slightly over five minutes; yet velocities of 50 or 100 miles per second should be easily detected. The results fail to show any certain indication of motion. The uncertainties of measurement of such masses are so large, however, that velocities of 5 or 10 miles per second would not be detected. It may be said with confidence that the velocities at right angles to the line of sight were not as great as 20 miles per second. A comparison of negatives of the corona extending over a larger interval of time—e. g., those secured in Mauritius and Sumatra—would be valuable in this connection.

C. D. PERRINE.

MT. HAMILTON, CALIFORNIA, 1902, March 17th.

ASTRONOMICAL TELEGRAMS.

(Translations.)

CAMBRIDGE, MASS., Feb. 2, 1902.

To Lick Observatory: (Received 4:30 P.M.)

Kiel cables that SCHWAB'S *Algol* variable 93, 1901, will be at minimum on Feb. 3.89 Green. M. T. Its period is 3.38 days.

(Signed) E. C. PICKERING.

CAMBRIDGE, MASS., Feb. 4, 1902.

To Lick Observatory: (Received 6:35 P.M.)

HALE telegraphs that PARKHURST found SCHWAB'S variable to be of magnitude 8.45 at $23^h\ 46^m$ G. M. T. Feb. 3; and of magnitude 8.10 at $0^h\ 29^m$ G. M. T. Feb. 4.

(Signed) E. C. PICKERING.

MOUNT HAMILTON, CAL., Feb. 10, 1902.

To Harvard College Observatory,
Cambridge, Mass. (Sent 9:45 A.M.)

PERRINE finds that the remarkable coronal disturbance seen at the Sumatra eclipse was immediately above the prominent and only sun-spot visible during eleven days.

(Signed) W. W. CAMPBELL.

MOUNT HAMILTON, CAL., March 13, 1902.

To Harvard College Observatory,
Cambridge, Mass.

(Sent 4:14 P.M.)

From recent Crossley photograph, PERRINE finds no evidence of polarization in condensations A and D of the nebula surrounding *Nova Persei*.

(Signed) W. J. HUSSEY, (in charge).

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in carrying out the work of this department. Communications of general interest will be gladly received, and may be sent to SIDNEY D. TOWNLEY, 2023 Bancroft Way, Berkeley, California.

Professor F. P. BRACKETT, kindly sent to the Society a report of the observations of the *Leonids* made by volunteers from the astronomy class of Pomona College, on the mornings of November 14, 15, and 16, 1901. Unfortunately, the manuscript was received too late for insertion in our last number. As the observations have since then been printed in *Popular Astronomy* (March, 1902, p. 165), we shall merely summarize them. In all, 1,590 meteors were seen on the three mornings, 1,483 of them being *Leonids*. The thick of the shower came between 3:00 and 5:30 A.M., November 15th, reaching a climax between 4:30 and 5:00 A.M., when 400 were seen in half an hour, the average interval being 4 seconds. The least time for ten meteors was 15 seconds from $4^h\ 0^m\ 15^s$ to $4^h\ 0^m\ 30^s$. The magnitude and depth of color both increased with the frequency. At the time of greatest frequency more than a quarter of them were of the first magnitude or brighter, and more than a score were seen whose magnitude, length of path, and general appearance were magnificent.

"Veröffentlichungen des Königlichen Astronomischen Rechen-Instituts zu Berlin, No. 16," has been issued recently. The title is "Tabellen zur Geschichte und Statistik der kleinen Planeten," and the work was prepared by Director BAUSCHINGER, with the collaboration of Dr. NEUGEBAUER. The work is arranged in about a dozen tables, and much interesting and useful information is given.

NOVA PERSEI.—In Number 81 of these *Publications* I gave a few notes concerning the progress of our knowledge of the new star in *Perseus*. This wonderful object is still of great interest, and nearly every astronomical journal brings forth an account of some new investigation.

Light Curve.—There is but little to add under this head. The brightness of the star is gradually decreasing. It is now (March 26th) between the eighth and ninth magnitude. Most observers seem to agree that the periodic variation of brightness which was so marked last spring has completely died out. The winter weather in Berkeley, however, has been so persistently bad that it has been impossible to make more than a few scattering observations. Dr. WILSON is continuing the collection and publication (in *Popular Astronomy*) of all the magnitude observations that have been made on the star.

Color.—A study of the color of the new star in *Perseus* has led to some interesting results. At greatest brightness, the color of the star was white; as it declined, it passed through yellow, orange, and red. Some observers report that it has a greenish tint now. The most complete investigation of its color has been made, I think, by Herr OSTHOFF, of Cologne, (*A. N.*, No. 3751). He has collected numerous observations — not all — and reduced them to a common scale, that of SCHMIDT. In this system the colors of stars are designated by the numerals 0 to 10 the significance being 0 = white; 1 = yellowish white, etc.; 9 = red, with least touch of yellow; 10 = red. OSTHOFF has plotted his results, and there is almost a complete correspondence between the resulting color-curve and the light-curve. During April and May, when the star showed the greatest variations of brightness, there were corresponding changes in color. At the minima the star was decidedly red, but there was a considerable tinge of yellow in its color at the maxima. For a change of one magnitude in brightness the color changed about 0.8 of a step.

Spectrum. — The spectroscope has provided a large amount of material, but no one as yet has made, as far as I know, a thorough discussion of it. This is, without doubt, a rich field for study, and it is to be hoped that some one will take it up soon. The changes in the spectrum are fully as interesting as those in the brightness and color. On the date of discovery the spectrum was continuous, with a few dark lines, but by February 25th there were both bright and dark lines. During March and April two distinct types of spectra were observed, called by PICKERING the normal spectrum and the peculiar spectrum, the chief difference between them being that in the normal one the continuous spectrum was very strong, while in the peculiar one the continuous spectrum was rather weak, and a few bright lines were very prominent, which, perhaps, was due to a fading out of the weaker lines rather than to any increased brilliancy of the brighter lines. H_β, H_γ, and H_δ were among the most prominent of the brightest lines. This peculiar spectrum has been called a gas spectrum. PICKERING and VON GOTHARD have found that the so-called normal spectrum was always seen at the time of the star's maximum of brightness and the peculiar (or gas) spectrum at the time of the minimum of light. SIDGREAVES finds, however, from a discussion of the observations made at Stonyhurst and at Oxford, that the changes of the spectrum follow not the phases of the light curve, but the absolute magnitudes of the star's brightness. He found that the peculiar spectrum always appeared when the brightness was less than 4.57 magnitude, and that the normal spectrum always returned when the magnitude became greater than 4.57. One spectrogram, taken when the magnitude was just 4.57 gave a spectrum showing some of the characteristics of both the normal and the peculiar spectra. In June or July the spectrum changed again, and then showed the characteristic lines of a planetary nebula. It has remained of that same nature since then.

One peculiar thing about the spectrum of *Nova Persei*, as well as of *Nova Aurigæ*, is that each bright hydrogen line is accompanied on the side toward the violet by a dark companion line. The interpretation given in 1892 was based upon DOPPLER'S well-known principle; that is, that we were observing two bodies, one giving a bright-line spectrum, the other a dark-line spectrum, and the one was moving toward us and the other away from us. The displacement of the lines, however, was large and velocities from 1,000 to 1,500 kilometers per second were necessary in this explanation. This state of affairs might subsist for a few days, but hardly for several months, as was observed in the *Nova Aurigæ*. Two other new stars discovered subsequent to *Nova Aurigæ* exhibited the same kind of spectra, and the new star of 1600, *P. Cygni*, which is still visible as a faint star, showed upon investigation the same spectrum also. Other explanations are now offered, and one of the most rational of these seems to be that proposed by Professor WILSING, of Potsdam. HUMPHREY and MOHLER found from laboratory experiments that the wave-length of a line could be changed by pressure. They were able to employ pressures of twelve atmospheres, but the displacement was very slight. WILSING was able to obtain much greater pressure by utilizing the disruptive discharge between metallic electrodes in water, which occurred with explosive violence and caused a rise of several hundred atmospheres in the pressure of the spark. In this way he was able to obtain displacements comparable with those found in new stars. WILSING and VOGEL have explained the conditions of a star necessary to give these great pressures. (See *Sitzungsberichte der k. Akademie der Wissenschaften zu Berlin,* May and July, 1899; also, *Astrophysical Journal,* Vol. X, pp. 113, 269; Vol. XIII, p. 217.)

Parallax.—No definitive determination of the parallax of the *Nova* has yet been made. Such as have been made, however, show that it must be exceedingly small, and Professor KAPTEYN thinks that it cannot be over one or two hundredths of a second of arc.

Nebulosity.—Several theories have been offered to explain the motions discovered by PERRINE in the nebula about the *Nova.* If we think that there has been an actual displacement of matter, and admit that the parallax does not exceed one or two hundredths of a second, then velocities comparable with those of light are necessary to explain the observed displacements. This is hardly conceivable, but not on that account impossible.

Professor KAPTEYN has suggested (*A. N.*, No. 3756) a theory which has been very favorably received by many. He assumes that the nebulosity, which surrounds the star, has no, or only very little, light of its own, and explains that the effect observed on the photographic plate is that of reflected light from the star itself. When the star first broke forth into great brilliancy, the nebulosity lying nearest to the star would, of course, be made visible first; and as the light-waves traveled outward new portions would be made visible. At the same time, however, as the brilliancy of the star began to decrease, the inner portions of the nebula would become less brilliant or entirely invisible. We would then have portions of maximum brilliancy apparently traveling outward.

The chief source of difficulty with this explanation, according to KAPTEYN, is, will this reflected light be strong enough to affect a photographic plate? This question was fortunately soon answered by Professor SEELIGER, of Munich, (*A. N.*, No. 3759,) who explains that his investigations have led him to almost identically the same conclusions as were reached by KAPTEYN. SEELIGER states, also, that he has already investigated the illumination of a nebula by a star, and he applies the criteria to the case in hand. He found that if we had a star and a nebula at a distance such that the parallax were $0''.01$, then a star of the 10.4 magnitude would illuminate the nebulosity to a distance of $10''$, with an intensity, under certain conditions, of 10^{-7} times the brightness of the full Moon. Now, the *Nova* was, at its brightest, about twelve thousand times as bright as a star of the 10.4 magnitude, and SEELIGER finds that that would have been sufficient to illuminate the nebulosity to a distance of 1100″. A translation of KAPTEYN'S article is given in *Popular Astronomy*, March, 1902.

Professor WILSING has offered another explanation (*A. N.*, No. 3765). He thinks that we have here a manifestation similar to that exhibited in comets; that is, that the star is possessed of a repulsive force by which rarefied matter is driven off into space, as the matter of a comet is driven off into the tail by a supposed repulsive force of the Sun. The idea that tremendous repulsive or explosive forces may at times be active in a star has been expounded and developed recently by Professor VERY (*American Journal of Science*, January, February, March, 1902.)

S. D. T.

MINUTES OF THE SPECIAL MEETING OF THE BOARD OF DIRECTORS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE ROOMS OF THE SOCIETY, ON SATURDAY, NOVEMBER 30, 1901, AT 2 P.M.

President DOLBEER presided. A quorum was present.

The purpose of the meeting being the Fourth Award of the Bruce Gold Medal, the letters received from the Directors of the six nominating Observatories were submitted by the Secretary. After a careful consideration of the recommendations contained in these letters, the selection of the Medalist was made by ballot, and the following certificate of bestowal was signed by all Directors present:—

SAN FRANCISCO, November 30, 1901.

FOURTH AWARD OF THE BRUCE MEDAL.

We, the undersigned Directors of the Astronomical Society of the Pacific, hereby certify, that, in accordance with the Statutes for the bestowal of the Bruce Medal, a special meeting of the Board of Directors was held this day, at two o'clock P.M., for the purpose of awarding the medal for the year 1902; and that, the provisions of the Statutes relating to its bestowal having been complied with, the medal was awarded to —

G. V. SCHIAPARELLI,

for Distinguished Services to Astronomy, by the consenting votes of eleven Directors.

Signed: JOHN DOLBEER, W. W. CAMPBELL,* CHAS. S. CUSHING. A. H. BABCOCK, CHAS. B. HILL,* S. D. TOWNLEY,* E. J. MOLERA,* ROSE O'HALLORAN, C. D. PERRINE,* WM. M. PIERSON, F. R. ZIEL.

(* By proxy.)

Adjourned.

In answer to a letter addressed to Professor SCHIAPARELLI, notifying him of the action taken by the Directors, the following letter of acceptance was received:—

(TRANSLATION.)

MILAN, January 31, 1902

Honorable Sir: Please accept my sincere thanks for your letter of January 1st, containing the announcement that the Astronomical Society of the Pacific has bestowed upon me its gold medal. I hold this a very great honor, which I prize the more as my name is thus added to the list of other eminent astronomers for whom I have the highest admiration. I beg you, Honorable Secretary, to express my profound gratitude to the Astronomical Society of the Pacific and its Directors.

With great and sincere regards, I am, yours devotedly,

G. SCHIAPARELLI,
Milan Observatory.

To the Secretary of the Astronomical Society of the Pacific,
San Francisco.

MINUTES OF THE SPECIAL MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN HEARST HALL, AT BERKELEY, ON FRIDAY EVENING, FEBRUARY 21, 1902, AT 8 P.M.

The meeting was called to order by Vice-President TOWNLEY.

The chairman announced that the Bruce Medal for the year 1902 had been awarded to Professor G. V. SCHIAPARELLI, of Milan, and that the reasons for the award would be given by the President in his address at the annual meeting in March. He also informed the members that the sum of $500 had been bequeathed to the Society by the last will of the late Mr. MORRIS REIMAN, of Chicago, who had been an active member of the Society for many years. He then introduced the lecturer of the evening.

Dr. W. W. CAMPBELL, Director of the Lick Observatory, gave an account of the meeting of the Astronomical and Astrophysical Society of America, recently held in Washington, which he attended as the representative of the University of California. After giving a summary of the papers presented and of the conclusions arrived at by the subsequent discussions of some of the subjects, he exhibited a large number of beautiful transparencies on glass, representing the photographic work done at the Lick Observatory in recent years.

The meeting then adjourned.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, MARCH 29, 1902, at 7:30 P.M.

Mr. DOLBEER presided. A quorum was present. The minutes of the last meeting were read and approved. The following members were duly elected:—

LIST OF MEMBERS ELECTED MARCH 29, 1902.

Mr. JOHN PATTEN	28-40 S. Front St., Baltimore, Md.

The Secretary reported that, in order to comply with a recent ruling of the Post Office Department regarding second-class mail privileges, it has become necessary to discontinue the printing of advertisements in the *Publications*.

It was, upon motion, resolved that the printing of advertisements be discontinued.

MINUTES OF THE ANNUAL MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE ROOMS OF THE SOCIETY, MARCH 29, 1902, AT 8 P.M.

The meeting was called to order by President DOLBEER. A quorum was present. The minutes of the last meeting were approved. The Secretary read the names of new members duly elected at the Directors' meeting.

The following papers were presented:—

1. Address of the retiring President, by JOHN DOLBEER.
2. Reports of Committees: on Nominations; on the Comet-Medal; on Auditing; and Annual Report of the Treasurer.
3. Astronomical Observations in 1901, by TORVALD KÖHL.
4. Planetary Phenomena for May and June, 1902, by MALCOLM MCNEILL.

The Committee on Nominations reported a list of names proposed for election as Directors, as follows: Messrs. R. G. AITKEN, A. H. BABCOCK, W. W. CAMPBELL, CHAS. S. CUSHING, A. O. LEUSCHNER, E. J. MOLERA, Miss R. O'HALLORAN, Messrs. C. D. PERRINE, WM. M. PIERSON, S. D. TOWNLEY, F. R. ZIEL.

For Committee on Publication: Messrs. R. G. AITKEN (Chairman), J. D. GALLOWAY, FRANK SCHLESINGER.

Messrs. RICHARDSON and BRASCH were appointed as tellers. The polls were open from 8:15 to 9 P.M., and the persons above named were duly elected to serve for the ensuing year.

REPORT OF THE COMMITTEE ON THE COMET-MEDAL, SUBMITTED APRIL 1, 1902.

This report relates to the calendar year 1901. The comets of 1901 have been:—

Comet *a* (unexpected comet) discovered April 23d, at Queenstown, South Africa, the name of the first discoverer being as yet unknown. The comet was a conspicuous object, and was independently discovered by many persons in the Southern Hemisphere. The Comet-Medal has not yet been awarded.

Comet *b* (ENCKE's periodic comet) was rediscovered on August 5th, by Dr. H. C. WILSON, of Goodsell Observatory, Northfield, Minn.

Respectfully submitted,

W. W. CAMPBELL (*ex-officio*),
WM. M. PIERSON,
CHAS. BURCKHALTER,
The Committee on the Comet-Medal.

The Treasurer submitted his Annual Report as follows:—

Annual Statement of the Receipts and Expenditures of the Astronomical Society of the Pacific for the Fiscal Year ending March 29, 1902.

GENERAL FUND.

Receipts.

Cash Balance, March 31, 1901			$71 19
Received from dues		$ 991 92	
" " sale of publications		112 20	
" " " " stationery		65	
" " advertisements		25 00	
" " Security Savings Bank (interest)		30	
" " Life Membership Fund (interest)		52 01	
" " Lick Observatory, for two cuts 1898 Eclipse		7 00	
" " Donohoe Comet-Medal Fund (postages on medals Nos. 1-40)		20 00	
		$1,209 08	
Less transfer to Life Membership Fund		50 00	1,159 08
			$1,230 27

Expenditures.

For Publications: printing Nos. 78 to 81 of Vol, XIII	$613 65		
" " illustrations	44 45	$ 658 10	
Stationery and printing		37 30	
Postages		50 71	
Rent		180 00	
Salary Secretary-Treasurer		180 00	
Expressages		3 50	
Janitor and elevator		2 50	
Gas		1 00	
Taxes		2 44	
Insurance premiums		21 25	
Lecturer's expenses		5 00	
Lantern at lecture		8 50	
Engrossing diplomas		2 50	
Bank exchanges		20	1,153 00
Cash Balance, March 29, 1902			$77 27

LIFE MEMBERSHIP FUND.

Cash Balance, March 31, 1901	$1,603 95
Received from General Fund	50 00
Interest for 1901	52 01
	$1,705 96
Less transfer to General Fund (interest)	52 01
Cash Balance, March 29, 1902	$1,653 95

DONOHOE COMET-MEDAL FUND.

Cash Balance, March 31, 1901		$684 13
Interest for 1901		22 34
		$706 47
Less engraving medal No. 40	1 00	
" transfer to General Fund (postages on medals Nos. 1-40)	20 00	21 00
Cash Balance, March 29, 1902		$685 47

BRUCE MEDAL FUND.

Cash Balance, March 31, 1901	$2,577 97
Interest for 1901	78 25
	$2,656 22
February 19, 1902, Remittance to A. Dubois, for one gold medal (fourth award)	102 15
Cash Balance, March 29, 1902	$2,554 07

ALEXANDER MONTGOMERY LIBRARY FUND.

Cash Balance, March 31, 1901		$1,543 26
Interest for 1901		50 13
		$1,593 39
Less expenditures:		
Popular Astronomy, subscription Vol. 10	$ 2 50	
Book-shelves (see resolution, page 85, Vol. XIII)	31 50	34 00
Cash Balance, March 29, 1902		$1,559 39

FUNDS.

Balances on Deposit as follows:

General Fund:		
with Donohoe-Kelly Banking Co	$66 93	
" Security Savings Bank	10 34	
		$77 27
Life Membership Fund:		
with San Francisco Savings Union	$603 95	
" German Savings and Loan Society	450 00	
" Hibernia Savings and Loan Society	600 00	
		$1,653 95
Donohoe Comet-Medal Fund:		
with San Francisco Savings Union	$213 99	
" German Savings and Loan Society	230 61	
" Hibernia Savings and Loan Society	240 87	
		$685 47
Alexander Montgomery Library Fund:		
with San Francisco Savings Union	$507 19	
" German Savings and Loan Society	411 81	
" Hibernia Savings and Loan Society	640 39	
		$1,559 39
Bruce Medal Fund:		
with San Francisco Savings Union	$1,274 58	
" Security Savings Bank	638 34	
" German Savings and Loan Society	641 15	
		$2,554 07
		$6,530 15

SAN FRANCISCO, March 29, 1902.

F. R. ZIEL, *Treasurer.*

Examined and found correct.

CHAS. S. CUSHING, } *Auditing Committee.*
F. H. MCCONNELL, }

The report was, on motion, accepted and filed.

The Committee appointed to audit the Treasurer's accounts reported as follows, and the report was, on motion, accepted and adopted:—

SAN FRANCISCO, CAL., March 29, 1902.

To the President and Members of the Astronomical Society of the Pacific:

GENTLEMEN — Your committee appointed to audit the accounts of the Treasurer for the fiscal year ending March 29, 1902, has, after a careful examination, found the same to be correct. Your committee further reports that the books of the Treasurer were found to be in first-class condition, correctly indicating the status of each of the various funds, and that proper vouchers were on file accounting for all moneys expended.

Respectfully submitted,

CHAS. S. CUSHING, } *Committee.*
F. H. MCCONNELL, }

The President then presented his annual address.

The following resolution was, on motion, adopted:—

Resolved, That all the acts appearing in the minutes of the meetings of the Board of Directors of this Society, as having been done by said Board during the past fiscal year, are here now, by this Society, approved and confirmed.

Adjourned.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, MARCH 29, 1902, AT 9:30 P.M.

The new Board of Directors was called to order by Mr. TOWNLEY. A quorum was present. The minutes of the last meeting were approved.

The business in hand being the election of officers and committees for the ensuing year, the following officers and committees, having received a majority of the votes cast, were duly elected:—

President: Mr. C. D. PERRINE.
First Vice-President: Mr. S. D. TOWNLEY.
Second Vice-President: Miss R. O'HALLORAN.
Third Vice-President: Mr. CHAS. S. CUSHING.
Secretaries: Messrs. R. G. AITKEN and F. R. ZIEL.
Treasurer: Mr. F. R. ZIEL.

Committee on the Comet-Medal: Messrs. CAMPBELL (*ex officio*), PIERSON, and BURCKHALTER.

Library Committee: Mr. TOWNLEY, Miss O'HALLORAN, Mr. BRASCH. Mr. TOWNLEY was appointed Librarian.

Finance Committee: Messrs. PIERSON, CUSHING, BABCOCK.

The Committee on Publication is composed of: Messrs. R. G. AITKEN, J. D. GALLOWAY, FRANK SCHLESINGER.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. C. D. Perrine	*President*
Mr. S. D. Townley	*First Vice-President*
Miss R. O'Halloran	*Second Vice-President*
Mr. Chas. S. Cushing	*Third Vice-President*
Mr. R. G. Aitken Mr. F. R. Ziel	*Secretaries*
Mr. F. R. Ziel	*Treasurer*

Board of Directors—Messrs. Aitken, Babcock, Campbell, Cushing, Leuschner, Molera, Miss O'Halloran, Messrs. Perrine, Pierson, Townley, Ziel.

Finance Committee—Messrs. Pierson, Cushing, Babcock.

Committee on Publication—Messrs. Aitken, Galloway, Schlesinger.

Library Committee—Mr. Townley, Miss O'Halloran, Mr. Brasch.

Committee on the Comet-Medal—Messrs. Campbell (*ex-officio*), Pierson, Burckhalter.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. Ruthven W. Pike.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. Felipe Valle.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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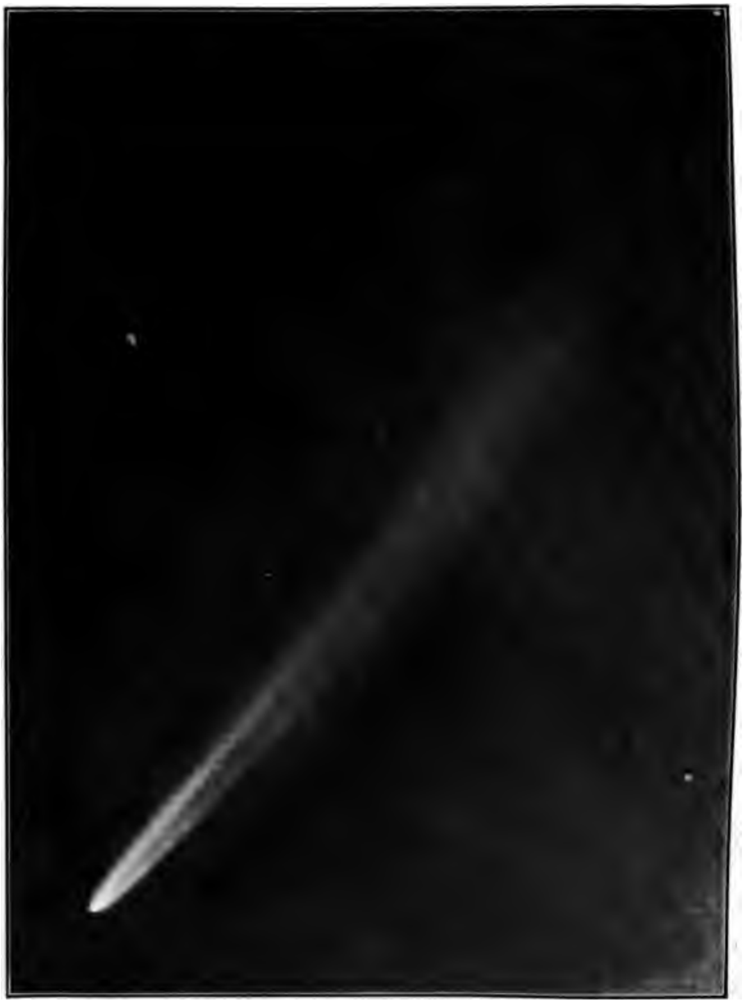

THE GREAT SOUTHERN COMET OF 1901.

From a photograph taken at Padang, May, 1901, by C. D. PERRINE.

PUBLICATIONS
OF THE
Astronomical Society of the Pacific.

VOL. XIV. SAN FRANCISCO, CALIFORNIA, JUNE 1, 1902. NO. 84.

THE FLASH SPECTRUM.

BY S. A. MITCHELL.

Advances in the "new astronomy" were very rapid after 1859, when KIRCHHOFF formulated the laws of spectrum analysis. In a communication to the Royal Society, April 23, 1868, HUGGINS gave the first tangible results in the movements of approach and recession between the Earth and the stars, thus confirming the Doppler-Fizeau principle, announced about a quarter of a century earlier. In the same year, on August 18th, the spectroscope was first applied to a study of the Sun during a total eclipse. We are all of us familiar with JANSSEN's observations of the spectrum of prominences, with the fact that he saw these "red flames" the next day without an eclipse, with their independent discovery by LOCKYER, and with the communication by the two distinguished scientists of their results to the same meeting of the French Academy. These discoveries make a most notable chapter in the history of astrophysics.

KIRCHHOFF's laws tell us that the dark lines of the solar spectrum are caused by the absorption of light of definite wave-lengths as the rays pass through the metallic vapors that surround the Sun. These vapors are at a high temperature, and if the more intense light of the Sun could be cut off by some means, these gases ought to shine of their own light, and give their spectrum of bright lines. Since these gases cause the absorption spectrum, the lines that appear bright in the emission spectrum ought to have the same positions as the lines that appear dark in the Fraunhofer spectrum, or, in other words, one spectrum is just the "reversal" of the other. Thus reasoned Professor YOUNG. Since the Moon cuts off the light of the Sun at a total eclipse, Professor YOUNG, before the eclipse of

1870, foretold the reversal of the spectrum at the instant the Sun was entirely covered up by the Moon, *i. e.* at the beginning of totality. We can perhaps imagine the feeling of joy experienced by him in having his investigations verified by seeing the bright lines flash out for a few seconds at the beginning and ending of the total phase. Indeed, a great triumph for the mind of man!

But how many of the lines were reversed? It seemed that the flash spectrum matched line for line the Fraunhofer spectrum; certainly the more prominent lines appeared dark in one spectrum and bright in the other; but it was impossible to determine in a few seconds whether *all* the lines of the absorption spectrum were seen also in the emission spectrum, or whether there were any lines in the latter that did not appear in the former. This question could be settled only by obtaining a permanent record of the flash spectrum by photography, which was accomplished for the first time in 1893 by FOWLER, in West Africa, and again in 1896 by SHACKLETON, in Novaya Zembla. From investigations of the photographs of these two eclipses, LOCKYER has found that in the region between F and K only three and eight per cent, respectively, of the lines in the solar spectrum were found in the flash. ("Recent and Coming Eclipses," p. 111.) He also found that the intensities of the lines of the two spectra were by no means the same, and decided, not, indeed, without excellent reasons, that the one spectrum was not the reversal of the other, and that the flash must therefore be due to some other cause than the shining out of the "reversing layer," which, by absorption, causes the Fraunhofer lines. LOCKYER, however, counted the number of lines in the solar spectrum from ROWLAND's maps, obtained by a much more powerful instrument than had been used at either eclipse,—a test, therefore, which was hardly a fair one.

The differences in intensity of the two spectra were indeed hard to explain. LOCKYER found that certain lines which appeared stronger in the flash than in the solar spectrum also were stronger in the spark than in the arc, and thought that "clearly, then, the chromosphere, as photographed in the eclipses of 1893 and 1896, is a region of high temperature, in which there is a corresponding simplification of spectrum, as compared with the cooler region in which the Fraunhofer absorption is produced" (*loc. cit.*, p. 111); but he does not make perfectly clear how it is that, when we go from the lower layers of the Fraunhofer spectrum *away* from the Sun to the higher region of the flash spectrum, we reach a higher temperature, instead of a cooler one, as we would naturally expect.

The important spectroscopic investigations at the Indian eclipse of 1898 were those of EVERSHED and LOCKYER, both of whom used prismatic cameras. Although the wave-lengths of the flash lines given by the two observers agree very well, the conclusions drawn from them differ as widely as possible. LOCKYER explains the differences of intensity, as he did in the two preceding eclipses, by saying that the Fraunhofer spectrum is connected with the temperature of the arc, while the flash is more nearly related to that of the spark. EVERSHED, on the other hand, accepts YOUNG'S original explanation of the "reversing layer," and gives as the cause of the intensity-variations the *heights* to which the vapors ascend above the Sun's surface.

The cause of these widely different explanations is found in the impossibility of always correctly identifying the flash lines. ROWLAND, by using concave gratings of high dispersion, has given a standard of excellence for the Fraunhofer lines, to which as yet, for the flash spectrum, we have been able to approach only very distantly. Photographs of the flash have been taken with a much smaller dispersion than that of ROWLAND'S maps, with the focus at times none too exact, so that it is not at all surprising that individual flash lines have been assigned by different observers to different elements. It is only through better determination of wave-lengths that we will arrive at the correct interpretation of the solar phenomena.

The only results of the eclipse of 1900 so far published are those of FROST (*Astrophysical Journal*, Vol. 12, 307-351, 1900). His investigations do not show to him any foundation for the stress LOCKYER places on "enhanced" lines in connection with the flash, but, on the other hand, lead him to again confirm YOUNG'S investigations.

In view of these problems of great interest to astronomers, it was with great pleasure that the writer accepted the invitation to become a member of the expedition sent out by the U. S. Naval Observatory to view the Sumatra eclipse of May 18, 1901. The party consisted of eleven—six members of the observatory staff and five invited guests. The former included Professor A. N. SKINNER, U. S. N., in charge of the expedition; Professor W. S. EICHELBERGER, U. S. N.; Professor F. B. LITTELL, U. S. N.; Mr. G. H. PETERS, Mr. W. W. DINWIDDIE, and Mr. L. E. JEWELL, now of the Johns Hopkins University. The guests of the party were Professor E. E. BARNARD, of Yerkes Observatory; Dr. W. J. HUMPHREYS and Mr. H. D. CURTIS, of the University of Virginia; Dr. N. E. GILBERT, of Hobart College; and the writer.

A second party, from the Smithsonian Institution, consisting of Professor C. G. ABBOT and his assistant, Mr. P. A. DRAPER, accompanied the Naval Observatory members, the two parties sailing together from San Francisco on February 16th. Government steamers carried the expeditions to their destination, —the United States army transport " Sheridan " via Honolulu to Manila, the United States steamer "General Alava" from Manila to Sumatra, which was reached April 4th.

Before arriving in the island it had been decided to occupy two stations for observations on the eclipse; one, Solok, near the central line of totality; the other, Fort de Kock, near the northern edge of the Moon's shadow-path.

When we arrived in the East Indies it was soon found that clouds were likely to be exceedingly troublesome, for at no time during the day was the sky perfectly clear. In view of this, it was thought best to subdivide the party at Solok, and a third station was selected at Sawah Loento, twenty miles beyond Solok, at the terminus of the " Staatsspoorweg op Sumatra," the government railroad running inland from Padang. At Sawah Loento were already located Mr. and Mrs. H. F. NEWALL, of Cambridge, England, and a party from the Massachusetts Institute of Technology, under the direction of Professor BURTON.

The eclipse station was situated 1,250 feet above sea-level, the latitude and longitude being:—

0° 41′ 52″ South,
100° 46′ 40″ or $6^h\ 43^m\ 6^s.7$ East.

The duration of totality was calculated at five minutes and forty-one seconds.

The main work at Sawah Loento was spectroscopic. The spectroscope consisted of a Rowland flat grating of 15,000 lines per inch, having a ruled surface of $3\frac{1}{2} \times 5$ inches, and a quartz lens of $3\frac{3}{8}$ inches aperture and 72 inches focal length, made by BRASHEAR, the whole apparatus belonging to the Naval Observatory. The grating was employed in the manner which gives a normal spectrum, which is the case when the diffracted ray leaves the grating perpendicularly, or the angle of diffraction is zero. The attempt was made to photograph the first order spectrum from λ 3000 to λ 6000, hence with λ 4500 at the center of the plates.

The day of the eclipse dawned clear, and our hopes were that these favorable conditions would remain till after totality, which occurred shortly after noon. First contact was observed in a perfectly cloudless sky, but soon after this clouds began to gather, and a quarter of an hour before second contact the sky was completely overcast.

The disappearing crescent of the Sun was watched by a binocular, before one half of which was arranged a small plane grating in such a way that with one eye the spectrum could be seen, with the other the Sun itself. With this, shortly before the time of second contact, bright lines were seen for a few seconds at F and H and in several places in the green and yellow, but these disappeared almost immediately,—the Sun being completely hidden by clouds,—and the first flash passed without our being able to see it.

Towards the middle of totality conditions became a trifle better, so that it was possible to see, through clouds, the corona extending for about half a diameter from the Sun, and with the small spectroscope the "coronium" line could be seen quite distinctly. During no time of the five minutes and forty-one seconds of totality was an unclouded view of the corona obtained, but, nevertheless, the second flash was seen beautifully. An hour after the total phase the clouds cleared away, and a perfect sky remained for the rest of the day.

Altogether eight plates—or, rather, films—were exposed, —one before and one just after totality for the cusp spectrum, one at first and one at second flash, and four during the total phase, with exposures of 12^s, 120^s, 90^s, and 45^s, respectively.

The first plate was taken ten seconds before the computed time of the second contact, and was exposed for one half second. It shows the cusp spectrum and about sixty lines between F and H.

As noted above, the clouds thickened at an inopportune time, with the result that nothing appears on the plate exposed for the flash. The four plates exposed during totality show continuous spectrum of a width equal to the diameter of the Sun, and extending from about λ 4900 to λ 3400, also bright lines of hydrogen from $H\beta$ to $H\eta$ and the helium line λ 4471.6 undoubtedly due to the upper chromosphere.

The second flash seemed fully exposed in spite of the clouds.

An exposure was made as soon after totality as possible,—probably five seconds after third contact,—for the cusp spectrum. An exposure of one half second was given, the plate closely resembling that made before second contact.

For some reason the spectra were not all of them in perfect focus. As absorption lines suffer from this defect more than bright lines, it was found practically impossible to measure the cusp spectra. For wave-lengths, we are therefore confined to one plate,—that of the second flash. This was exposed for three seconds, the exposure being stopped at the first reappearance of the Sun.

The peculiarities of this photograph of the flash are twofold: (1) The normal spectrum, and (2) the great dispersion.

On the plate the distance from F to H is 95.4^{mm}, and as the spectrum is normal, 1^{mm} therefore corresponds to a difference of wave-length of 9.37 tenth-meters, or 1 tenth-meter corresponds to a dispersion of about 0.1^{mm}. This dispersion is about one fifth of that obtained with the ordinary Rowland mounting with a grating of 20,000 lines and radius of 21½ feet.

The plate was measured with one of the Repsold machines belonging to the Columbia University Observatory, by comparing the position of the spectrum lines directly with a millimeter scale. Measures with this machine can be made directly to 0.005^{mm}, and by estimation to 0.0005^{mm}, *i. e.* to 0.005 λ; the sharpness of the lines, however, did not permit them to be carried to quite this degree of exactness.

Although the spectrum was not in the most perfect focus, in view of the great dispersion measures could be made with a high degree of accuracy. Wave-lengths were determined by taking well-defined standards properly distributed, whose wave-lengths were taken from ROWLAND'S table of standard wavelengths. Three independent measures of the plate were made.

Second and third contacts were not 180° apart, and the instrument was set up to make a compromise between the two positions.. This is the reason for the inclination of the lines of the flash.

Those who have attempted to identify the bright lines with ROWLAND'S map know the difficulty of this undertaking. Great care was exercised in the determinations of the wave-lengths, and in the comparisons with ROWLAND'S tables. For the flash an arbitrary scale of intensities was taken, where 0 means a line seen with certainty, 10 the strongest line, 00 denotes a line seen with difficulty.

In comparing wave-lengths of the flash spectrum with those of the solar spectrum, it is necessary to bear in mind two points: first, we are dealing with a dispersion of about one fifth of ROWLAND'S, with the focus not so exact, and therefore it will be impossible to separate in the flash the counterparts of close dark solar lines; second, the emission and absorption lines are formed at different heights above the Sun's surface, and the emission lines will, as a result, be shifted (in this flash) towards the violet.

The focus is best between F and H, and for the present purpose this region only will be considered. Neglecting *H* and *He* lines and those lines identified with groups, 374 lines were measured in the flash between F and H. Ninety-one of these were unidentified, and 283 were identified with lines in the solar spectrum.

Two points are immediately noticed in comparing the two spectra: first, for each and every element, the brighter the solar line the brighter the flash line corresponding to it; second, the intensities of the solar lines which correspond to a line of given brightness in the flash differ with different metals. *Fe* and *Ni* lines of intensity 5; *Ti, Sc,* and *V* lines of intensity 2 are identified with flash lines of equal strength. These differences for the various elements were so marked that in order to arrive at their significance, and hence draw some conclusions regarding the "reversing layer," comparisons were made between the flash and the solar spectrum.

Although we cannot directly compare the intensities of the bright lines of the flash (scale 0-10) with those of the dark lines given in ROWLAND'S tables (scale 1-1000), we arrive at certain theoretical considerations if we compare the ratios of the average intensities of the different elements,—that is, $\frac{\text{Flash intensities}}{\text{Solar intensities}}$, and also the ratio of the number of lines of each element identified to the whole number of solar lines for that metal. Forming these ratios and arranging them, we are at once struck with the systematic variations not only in the ratio of intensities, but also in the percentage of lines identified.

The meaning of these systematic differences will be understood if we consider these ratios in combination with the atomic weights of the various elements, as is done in the following table, where also are put down the number of lines of the flash due to each metal:—

GROUP I. LINES STRONG IN FLASH AND IN SOLAR SPECTRUM.

Element.	Atomic Weight.	Number of Lines Identified.	$\frac{\text{Intensity Flash.}}{\text{Intensity Solar Lines.}}$	$\frac{\text{Number of Lines Identified.}}{\text{Total Number of Lines.}}$
Na	23.0	—	—	—
Mg	24.3	1	0.10	1.00
Al	27.1	—	—	—
Ca	40.0	8	0.34	0.38

GROUP II. LINES STRONG IN FLASH, WEAK IN SOLAR SPECTRUM.

Sc	44.1	6	0.81	0.75
Ti	48.1	62	0.68	0.70
V	51.2	15	0.68	0.67
Cr	52.1	38	0.55	0.69
Mn	55.1	27	0.24	0.48
Sr	87.6	2	1.08	0.67
Y	88.7	2	0.50	0.67
Zr	90.6	9	0.46	0.70

GROUP III. LINES WEAK IN FLASH, STRONG IN SOLAR SPECTRUM.

Fe	56.0	125	0.20	0.32
Ni	58.7	9	0.36	0.28
Co	59.0	6	0.19	0.29

Looking at the numbers in the last two columns, we see that the lines naturally fall into three groups, as given in the above table.

To these may also be added the following lines:—

La, atomic weight 138.5, 3 lines at λ 4123.384, λ 4217.720 and λ 4613.544.

Ba, atomic weight 137, 1 line, at λ 4554.211; and the following lines possibly identified:

Si, atomic weight 12, 1 line, at λ 3905.660.

Zn, atomic weight 65, 1 line, at λ 4810.724.

Ce, atomic weight, 92, 2 lines at λ 4003.912 and λ 4107.649.

In Group I would also fall *Al*, if we consider the relative intensities of the two lines λ 3944.160 and λ 3971.674; and undoubtedly *Na*, if our plate took in the D lines.

The grouping of these lines is exactly that adopted by EVERSHED from his investigations of the Indian eclipse, except that I have put *Zr* with *Sr* and *V* in Group II. *Mn* seems to represent the transition from Group II to Group III.

Sir WILLIAM and Lady HUGGINS* called attention to the great heights to which *Ca* extends in the Sun's atmosphere, and it is on account of this great extent that H and K are such prominent lines, not only in the absorption spectrum, but in the emission spectrum. As EVERSHED† has pointed out, the remarkable variations of the relative intensities in the flash and Fraunhofer spectra are undoubtedly due to the *heights* to which the vapors of the different metals ascend in the chromosphere. We would naturally expect that these heights vary according to the atomic weights of the metals, those of least atomic weights ascending to the greatest distances; and, generally speaking, this no doubt is true. But if we have two gases in the Sun's atmosphere,—one a gas with an intrinsic brightness 1 and a layer 100 miles in thickness,—on the photograph there would result a line in the flash spectrum just as bright as for the other gas of intrinsic brightness 100 and only 1 mile thick, if the Sun and Moon were relatively at rest during the period of the "flash"; but considering the gradual advance of the Moon in covering successive layers of the Sun's atmosphere, we see that in the emission spectrum the photographic brightness of the fainter gas would be many times that of the brighter. The absorption caused by a gas depends on the total number of molecules the solar ray comes in contact with, and will be very nearly equal in the two cases.

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* Sir WILLIAM and Lady HUGGINS, "The relative behavior of the H and K lines of the spectrum of calcium," *Astrophysical Journal*, Vol. 6, 77, 1897.

† EVERSHED, "Wave-length determinations and general results obtained from a detailed examination of spectra photographed at the solar eclipse of January 22, 1898," *Phil. Trans. Royal Society*, A, Vol. 197, 381-413, 1901.

In view of these considerations, it would therefore seem that the gases of the metals of Group II extend very high, that they are nowhere very much condensed, and that practically all the gas contributes to the formation of the emission line; and hence the flash lines are to be regarded as true reversals of the corresponding solar lines.

The vapors of Groups I and III are somewhat condensed near the Sun's surface (those of Group I, particularly *Ca*, reach far greater heights than those of Group III), but as it is the upper portions that contribute most to the formation of the emission lines, owing to the progressive motion of the Moon, the flash lines are to be regarded as only partial reversals of the Fraunhofer lines, the solar intensities being greater than the flash intensities.

Taking account of lines in the flash identified with groups in the solar spectrum, about half the solar lines have corresponding lines in the flash. From the above considerations, we see that it is highly improbable that lines of intensity 2 on ROWLAND'S scale in the solar spectrum, and belonging to Groups I and III, will have flash lines corresponding to them of sufficient brightness to show in this flash. In fact, although there are 135 *Fe* lines of intensity 2 between F and H, only eleven of these are found in the flash; and, indeed, great numbers of the feebler solar lines are lacking in the flash. But if, on the other hand, we compare the stronger lines, we see that every strong line of the solar spectrum is almost without exception found in the flash spectrum.

And so, remembering the meaning of the differences of intensities, we see no reason for giving up our faith in the existence of the "reversing layer."

We may obtain an approximate estimate of the depths of the layers producing the bright arcs by measuring the angular extent of the arcs. Accordingly, the lengths of some of the more conspicuous bright lines have been measured, and thence were deduced the elevations of the luminous layers producing the bright lines of the flash spectrum. In calculating, the semi-diameter of the Sun was taken as 948″.4, and the Moon's augmented semi-diameter 1013″.8. For the purposes of comparison, the same arcs were taken that Frost* has measured. The depths of the luminous layers of the various metallic vapors come out as follows:—

Spectrum line...	*H* 3970	*He* 4026	*Sr* 4078	*Hδ* 4102	*Sr* 4215	*Ca* 4226	*Sc?* 4247	*Fe pair* 4250	*Cr* 4254
Approximate height of layer	8"	4"	4"	7"	4"	2".5	2".5	< ½"	2".5
Spectrum line...	*Cr* 4274	*Sc* 4321	*Hγ* 4340	*Ti* 4395	*He* 4471	*Ti* 4501	*Ti* 4549	*Ba* 4554	*Hβ* 4861
Approximate height of layer	2"	2"	8"	2"	7"	2"	2"	2."5	8"

Comparing these heights with the intensities given in my scale (0—10), it is seen that, roughly speaking, the height in seconds of arc is 0.8 of the value of the intensity for Group II, and 0.4 for Groups I and III. The arcs of the great majority of the lines are no longer than the *Fe* pair at λ 4250, which correspond to an extent of ½".

As a result we may safely infer that the average depth of the "reversing layer" is about 1", although from the above considerations we see that the heights to which the gases extend and their condensations are different for the different elements.

These results differ materially from those of Sir Norman Lockyer. He lays great stress on the fact that great numbers of "enhanced" lines, or lines stronger in the spark than in the arc spectrum, are found in the spectrum of the chromosphere. In order to investigate this idea, close comparisons were made between the above flash lines and the latest list of "enhanced" lines given by Lockyer in *Proc. R. S.*, Vol. 65, 452, 1900.

Taking up first titanium, as the "enhanced" lines for this metal are most numerous, it is found that he has given fifty-three lines between λ 3900 and λ 4590. This region is all included in the photographs of the flash. Thirty out of the fifty-three "enhanced" lines certainly appear as bright lines in the flash, eleven do not appear, the other twelve are doubtful, from their proximity to strong flash lines, or from their being situated in a group in the flash. Thus 56 per cent of the "enhanced" lines of *Ti* are found as chromosphere lines; and this would seem to strongly support LOCKYER's views. But, on the other hand, every one of these thirty lines, without exception, appears as a strong line in the solar spectrum; and the coincidence between "enhanced" and flash lines does not prove anything definite, for where there are strong Fraunhofer lines we expect strong reversals in the flash. A real test would be the case where there is a strong "enhanced" line, but no strong solar line corresponding to it. Such a line occurs in titanium at λ 4308.60, where the intensity in the spark is 7, and on the same scale in the arc 1-2. There is a line in ROWLAND's tables at λ 4308.601 with an intensity of 00, but there is certainly no exceptionally strong flash line which we would be led to expect if LOCKYER's idea is correct. The appearance of this line may be contrasted with that at λ 4563.94. Both have the same intensity in the spark (*loc. cit.*), but to λ 4563.94 corresponds a strong line of intensity 4 on ROWLAND's scale, and a strong reversal in the flash of intensity 5 on my scale.

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* *Astrophysical Journal*, Vol. 12, 346, 1900.

The conclusions from the "enhanced" lines of iron agree with those for titanium, *i. e.* there are a great number of strong lines in the flash spectrum corresponding to the "enhanced" lines, but they also correspond to strong Fraunhofer lines.

A severe test of the idea that "enhanced" lines are found with great frequency in the spectrum of the chromosphere will be given by the metal vanadium. LOCKYER gives twenty-five lines between λ 3885.05 and λ 4243.10, the majority of which are decidedly stronger in the spark than in the arc. Only four of these lines are with certainty found in the flash, corresponding to LOCKYER's lines at λ 4005.85, λ 4035.80, λ 4225.41, and λ 4243.10. The first two of these have corresponding strong solar lines; the second two have not; none of the four lines, however, are identified by ROWLAND as due to vanadium. Three out of nineteen "enhanced" lines of manganese are found in the flash.

From these comparisons it would seem that there is no close connection between "enhanced" lines and the bright lines of the chromosphere seen in the flash.

When several reasons are advanced to explain the same phenomenon, that one is most readily accepted which is the simplest, which most easily follows the observed facts, and which tends to fewest or no contradictions. Three different explanations are given for the flash spectrum. The first is the original idea of YOUNG'S,—that the chromospheric spectrum is merely the flashing out of the reversing layer, the differences of intensities being easily explainable by the different heights to which the layers of the different vapors extend above the Sun's surface. The prominence of "enhanced" lines in the flash spectrum does not seem to be quite as pronounced, from the above investigations, as LOCKYER would have us believe, and there seems, therefore, no solid foundation for the idea that the flash spectrum is at a higher temperature than that of the Fraunhofer spectrum, even if it is farther away than the "reversing layer" from the hot Sun towards the cold of interstellar space. The difficulties in the way of accepting the explanation of JULIUS, as given in the *Astrophysical Journal* for February, 1902, are that we so far have been able to find in the laboratory anomalous dispersion for only one metal, sodium, (although this does not say it may not be found for others); that no photographs have shown the doubling of the lines in the flash spectrum, except those of tne Dutch party at the Sumatra eclipse, and that the doubling, if seen, could be so much more easily explained from the lack of perfect focus.

Taking all things into consideration, it seems much easier to explain the flash spectrum, as did Professor YOUNG, as a reversal of the Fraunhofer spectrum.

COLUMBIA UNIVERSITY, May 15, 1902.

SOME NEW ASTRONOMICAL INSTRUMENTS.

BY FRANK SCHLESINGER.

I. THE REGISTERING MICROMETER.—The greatest obstacle in the way of more accurate determinations of Right Ascensions is the observer's personal equation, which causes him to estimate the time of a star's transit always too early or always too late. Were the personal equation constant for each observer for a reasonably long period, things would not be so bad; but it has been known to vary in the course of a single night, besides depending upon the brightness of the observed object, and even upon the steadiness of the atmosphere. REPSOLD, the head of the famous firm of instrument-makers of that name, has constructed an instrument, called the registering micrometer, which is intended to do away entirely with personal equation. Instead of the ordinary reticule seen in the eye-piece of a transit instrument, the registering micrometer has a single movable thread, which the observer sets upon the star as soon as it appears; and he keeps the image constantly bisected (during the minute or so that it takes the star to traverse the field) by steadily turning the screw to which the thread is attached. This screw is so constructed that it automatically records a signal upon a chronograph sheet every time it completes a turn, or even more often, if desired.

This micrometer has been tested by Dr. ALBRECHT and three others of the staff of the Potsdam Geodetic Institute. The differences of personal equation between each pair of these observers were first determined with the ordinary reticule and then with the new micrometer, with these results:—

DIFFERENCES OF PERSONAL EQUATIONS.

			With Ordinary Reticule.	With Registering Micrometer.
ALBRECHT	*minus*	BORASS	—0^{s}.108	—0^{s}.004
ALBRECHT	"	GALLE	—0.314	—0.035
ALBRECHT	"	SCHNAUDER	—0.184	—0.027
BORASS	"	GALLE	—0.225	+0.013
BORASS	"	SCHNAUDER	—0.086	—0.023
GALLE	"	SCHNAUDER	+0.109	—0.006

It will thus be seen that the personal equation is gotten rid of, or at least is nearly the same for all observers. Dr. ALBRECHT also finds that the instrumental constants (collimation, flexure, etc.) can be more accurately determined with the new micrometer. In conjunction with Dr. BORASS he has determined the difference of longitude between Potsdam and Bucharest, and between Potsdam and the Poulkova Observatory. The results show surprisingly small probable errors.

A still further improvement has been made by providing the micrometer with clockwork to move the thread across the field. As the rates with which stars apparently move are different in various parts of the sky (those nearest the equator moving fastest), the clockwork must be adjustable to the declination of the star. The observer bisects the image as soon as it appears and then sets the clockwork going. The thread will now approximately bisect the image during the whole of its transit. It will not do so exactly, because of the unsteadiness of the atmosphere and because of irregularities in the clockwork itself; these the observer must counteract by hand, turning the screw slightly to and fro. This arrangement has been tried by the astronomers at Königsberg, by whom also it was devised. As might be expected, the addition of the clockwork has added to the already great accuracy of the instrument.

It is interesting to note that the registering micrometer with clockwork was proposed as early as 1865 by CARL BRAUN, of Kalocsa, Hungary, but his paper on the subject does not seem to have met with the appreciation it deserved.

II. A NEW SHELTER FOR MERIDIAN INSTRUMENTS.—The registering micrometer is intended to improve Right Ascensions. It is in place here to mention a simple expedient by which it is hoped to get better determinations of the Declinations of stars. The importance of the temperature of the observing-room is attracting more and more attention,* and the desirability of open air observations has been pointed out. Three years ago, with this in view, the International Latitude Observatories (in latitude 39° 8′) were built with roofs which could be rolled entirely away from the instruments beneath. In erecting the new meridian-circle at the Cape of Good Hope, Dr. GILL has gone even further. The shelter for the instrument is of steel, and is built of two entirely separate parts, which meet in the meridian. When ready to observe, the two halves are rolled away from each other (the one east and the other west) by means of a small electric motor, and the instrument is thus left actually in the open air.

III. AUTOMATIC HEATING APPARATUS FOR SPECTROGRAPHS.—Another example in which temperature is of the first importance is afforded by spectroscopic observations for motion in the line of sight. The photographic exposures for this purpose sometimes last an hour or more. If the temperature of the prisms changes much in this time, their indexes of refraction also change, and consequently the lines in the spectrum become broad and ill-defined. The first to use artificial means to maintain the prisms at a constant temperature was DESLANDRES, of the Meudon Observatory. He inclosed the whole prism-box in a tight compartment and allowed water at a constant temperature to flow through it. A much less cumbersome device was that of LORD, of the McMillin Observatory, Columbus, who was the first to use electric heating. He encased the spectroscope in a wooden box, and so placed a thermometer that its bulb was near the prisms, while its graduated tube projected not only outside of the metallic box containing the prisms, but also outside the outer wooden box. It was not necessary, therefore, to remove the latter in order to read the temperature at the prisms. The wooden box was lined with a quantity of German-silver wire. As this substance is not a good conductor of electricity, it will become slightly heated when a mild current is passed through it. The observer watches the projecting thermometer, and if the temperature falls, he turns on the current long enough to bring it back to its original point. A simple improvement upon this arrangement was made by CAMPBELL. The bulb of the thermometer was placed outside of the prism-box, but still within the wooden box. By controlling the temperature in this region, the prisms themselves will really have a more even temperature than in the former arrangement. The idea of providing a thermostat which would automatically control the temperature of the prisms seems to have suggested itself to several observers. Dr. HARTMANN, has carried out this idea in connection with the new telescope at Potsdam in an especially ingenious manner. Into the open end of a thermometer-tube is inserted a platinum wire so arranged that its end may be set at any desired reading of the temperature scale. Another platinum wire is set permanently into the bulb of the thermometer and is in contact with the mercury. The free ends of these two platinum wires are connected with the opposite poles of a weak electric battery, the circuit also including a small electric magnet. It is clear that there will be a complete circuit only so long as the mercury in the tube remains in contact with the inserted wire,—that is, so long as the temperature does not fall beyond a certain point. When the circuit is broken the magnet releases its armature, and this in turn completes the circuit of the heating current. Thus, as soon as the temperature near the prisms falls, it is at once raised to its original point by the automatic action of the thermostat. Two independent heaters are used,—one on each end of the prism-box,—in order to insure a perfectly uniform temperature of the air surrounding the prisms. The whole spectroscope, including the two thermostats and the two heaters, is, of course, inclosed in a tight wooden box.

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* See, for example, Dr. TOWNLEY'S review of BAUSCHINGER'S "*Untersuchungen über die astronomische Refraction*," in No. 71 of these *Publications*.

IV. WRIGHT'S APPARATUS FOR PHOTOGRAPHING THE COMPARISON SPECTRUM.—The instrument we have just described enables the observer to devote almost all his attention and time to accurate guiding of the telescope. The only interruptions that need be made are for the purpose of photographing a comparison-spectrum (usually the spark-spectrum of iron) in immediate juxtapositon with the star's spectrum. It is generally regarded as desirable to photograph the comparison-spectrum once or twice after the exposure for the star has begun and once or twice before it is quite finished. To do this by the old methods, the observer must stop the exposure on the star, put the sparking apparatus into position, expose the plate to the spark, remove the sparking apparatus and resume the exposure on the star. All this takes considerable time and may possibly disturb the adjustment of the spectroscope. Mr. WRIGHT, of the Lick Observatory, has devised a neat method for introducing the spark-spectrum without stopping the exposure on the star. The middle part of the spectroscope slit is used for admitting the light of the star. On each side of this space is a little prism which reflects the light of a spark placed entirely to one side of the beam of light which comes from the star. Between each prism and its spark a small lens is inserted, so that an image of the spark is formed at the slit, just next to that part which admits the light of the star. In order to photograph the spark-spectrum, the observer simply turns on an electric switch for a few seconds. Mr. WRIGHT'S invention, like the automatic heating apparatus previously described, economizes the observer's time and attention; besides, it lessens the chance of deranging the spectroscope.

V. THE COLOR-SCREEN (for photographing with a visual telescope).—A telescope used for photography must have an objective which is corrected for the blue and violet rays of light, since to these the photographic film is most sensitive. Such a telescope is nearly useless for visual observations, because those rays to which the eye is sensitive, the yellow and the green, are not brought to a focus. On the other hand, a visual telescope (corrected for these latter rays) cannot ordinarily be used for photography. Mr. RITCHEY, of the Yerkes Observatory, has, however, pointed out a simple expedient by which this can be done. Immediately in front of the photographic plate is placed a sheet of plate glass, which is so colored as to be opaque to the blue and violet rays, while allowing the green and yellow to pass through with nearly undiminished intensity. The blue rays are cut out before they can reach the photographic plate, and are not allowed to blur the picture. Furthermore, Mr. RITCHEY uses isochromatic plates (which are much more sensitive to yellow light than ordinary plates), and thus the length of exposure is cut down. Nevertheless, even with isochromatic plates, considerably longer exposures are necessary than if the objective had in the first place been corrected for photography. Mr. RITCHEY has obtained some beautiful large-scale photographs of the Moon and other objects by means of a color-screen and the great visual refractor of the Yerkes Observatory.

VI. THE MEDIAL TELESCOPE.—This is the name applied by the inventor, Professor SCHUPMANN, of Aachen, to a refractor of peculiar construction. The objective of an ordinary refractor consists of two lenses of different densities. This combination is necessary in order to correct for spherical and chromatic aberration. In the medial telescope, however, the objective consists of one lens, and the light which falls upon it passes through uncorrected. Near the eye-piece is placed a somewhat complicated optical system, which not only corrects for spherical and chromatic aberration, but does it better than is possible with the ordinary objective. For, even with two lenses of different densities, it is not possible to correct entirely for chromatic aberration; there is left what opticians call the "secondary spectrum," the effect of which is to make the images somewhat indistinct in even the best of telescopes. With the medial telescope the secondary spectrum is greatly reduced in intensity. A telescope of this description has been built at Urania Observatory, in Berlin; its aperture is thirteen inches and its focal distance is sixteen feet. The secondary spectrum is only one-twentieth as intense as that in an ordinary refractor of these dimensions. It is reported to be of excellent definition and to give surprisingly faultless views of the planets, even under bad atmospheric conditions. By simply turning a small screw, the image of a star may be broadened out into its spectrum with any desired degree of dispersion. The advantages of this instrument are its almost perfect achromatism and its inexpensive construction. Its disadvantages are its small field and the great loss of light which arises from the character of its optical system.

VII. THE STEREOCOMPARATOR.—If we compare two photographs of the same region of the sky,—taken, say, with an interval of half a year,—they will, to all appearances, be counterparts of each other. It is true that each will be somewhat differently distorted by refraction and aberration, and perhaps by a change in the telescope. But all these effects are so small as to be scarcely perceptible, except by exact measurements, besides being gradual and continuous across the area of a plate. It is therefore clear that by comparing two such photographs we may at once detect stars with large parallaxes or large proper motions. Furthermore, if one plate shows an image that on the other plate either does not appear at all, or appears less strongly impressed, we at once suspect that we have to do with a variable or a temporary star.

Many methods for comparing two photographs have been proposed. BARNARD suggested that a *positive* be made of one of them, and that this be put film to film with the other negative. For most stars the black dots on the negative will be covered by the transparent dots on the positive, and those stars for which this coincidence does not occur can be at once detected. PICKERING proposed that one of the plates be exposed with its *glass side* toward the objective of the telescope, and that the other be taken in the ordinary way, with the *film* toward the objective. These may be placed film to film, with the two images of the same star nearly coinciding. Ordinary stars will thus look like double stars of equal components. Variable stars will appear single or of unequal components; and stars of large parallaxes or large proper motions will appear a little more widely double or a little less widely double than other stars. KAPTEYN, in his work for the Cape *Durchmusterung*, faced two ordinary photographs in the same direction, and viewed them through a telescope four and a half feet distant. The further plate was thus seen through the glass and the film of the nearer. TURNER, of Oxford University, proposed that the photographs be projected upon a large screen by means of two stereopticons, so that the images of the same star should nearly coincide. This method, like KAPTEYN's and the one to be described presently, has the advantage of not requiring specially made photographs: the original negative taken in the usual way may be used.

Some of these methods would appear to leave little to be desired. Yet the instrument used by Dr. WOLF, of Heidelberg, and called by him the *Stereocomparator* is even more convenient than any of these. This instrument is essentially nothing more than a stereoscope, that scientific toy with which we are all familiar. One of the photographs to be compared is viewed solely with one eye, and the other photograph solely with the other eye, in such a manner that the mind gets the impression of a single photograph in which the objects appear at definite distances. The first plate having been fixed in its holder, the second, by proper orientation and tilting, may be so adjusted as to give the stereoscopic effect. Only a limited area of each plate can be observed at a time, but without disturbing their adjustment the two plates may be moved together, so that all the parts of the photographs may be successively brought into view. Most, if not all, of the stars on the photograph will appear to lie in a single plane. But if there be present a star which has been shifted relatively to its neighbors by reason of its parallax or its proper motion, such a star will appear to lie either a little in front or a little behind the plane occupied by the other stars. Again, if a star have a fainter image on one plate than on the other, the eye receives an unpleasant shock, slight but unmistakable. By this means, variable or temporary stars are at once recognized. The scientific value of the stereocomparator may be said to be already proven; with its help Dr. WOLF has found two stars in the *Pleiades* which he suspects of large parallax or proper motions, and he has also published a list of ten suspected variables. The latter are all in *Orion,* which, besides the *Pleiades,* is the only region thus far examined. Incidentally, some novel effects may be obtained with the stereo-comparator. *Jupiter,* for example, may be made to appear much nearer than the fixed stars in the same field, with some of his satellites a little in front and some a little behind *Jupiter* himself.

OBSERVATIONS OF VARIABLE STARS.

By Rose O'Halloran.

The following estimates were made under favorable conditions with a four-inch lens, and may be of interest, though the exact dates of maxima and minima were sometimes unavoidably missed on account of clouds or the interference of high buildings.

S Ursæ Majoris.

A maximum of this long-known variable was predicted for April 18, 1901, but seems to have been a few days later.

1901. April 4. Equal to *g* of 9th mag.
April 8. Ditto.
April 16. Ditto.
April 18. About 8.7 mag.
April 25. Midway between *g* and *d* of 8th mag.

The comparison-stars used are those lettered on the Harvard charts.

V Coronæ.

In his third catalogue, Professor Chandler alludes to the phases of this variable near its màximum, when a magnitude of from 7.2 to 7.7 is usually attained. A maximum was predicted for April 3, 1901, but observations were not obtained until the following dates:—

1901. April 8. Of 9th mag.
April 16. Of 10th mag.
April 18. Ditto.
April 21. Ditto.
April 23. Ditto.
April 25. Dimmer than 10th mag

Its period being 356 days, a maximum was due about March 26th of this year; but on that date it was only of 10th magnitude, or very slightly brighter than the star 5′ south. On March 29th a similar estimate was obtained.

S Tauri.

The maximum of this variable, predicted for January 31st, was observed as follows:—

1901. Dec. 10, 15, 19, 30. } Invisible.
1902. Jan. 2, 4. }
Jan. 7, 10. Of 12th mag.
Jan. 26, 28, 31. } Brighter than the two adjacent stars, and probably of 10th mag.
Feb. 2. }

R Tauri.

The minimum was predicted for December 28, 1901.

1901. Dec. 10, 15, 19, 30. Invisible.
1902. Jan. 2. A star of 12th mag., in the place of the variable, is discernible.
Jan. 4, 7, 10. } Ditto.
Feb. 2. }

W Aurigæ.

1901. Dec. 10, 12, 15, 18, 30. } Brighter than the two stars of 11.5 mag., with which it forms a triangle.
1902. Jan. 2. }
Jan. 4, 6, 7, 12, 17. Of 11th mag.
Jan. 25, 26, 31. Of nearly 10th mag.

The maximum predicted for March 15th in the *Companion to the Observatory* was unavoidably missed, but no doubt was seen elsewhere.

V Orionis.

Though this orb sometimes attains a magnitude of 8.4, the brightness was probably much less on the 18th of last January, the date of the predicted maximum.

1902. Jan. 4, 6, 7, 8, 10, 12, 15, 16, 19, 26, 27. Of 10.5 mag.
Jan. 28, 29. Of 11th mag.
Jan. 31. } Of 10.5 mag.
Feb. 2. }

The star south preceding, to which attention is called in *Popular Astronomy* for January, 1895, page 217, was of about 12th magnitude on the above dates.

W Lyræ.

This variable seems to have attained its maximum luster some weeks before the 9th of March, for which it was predicted in the *Companion to the Observatory.*

1902.	Jan. 11.	About half a mag. brighter than *n*, which is 8.1 mag.
	Jan. 20.	Equal to *n*; brighter than *a* of 8.6 mag.
	Jan. 27.	Ditto. Morning very clear. *W* seems yellowish in color.
	Feb. 12.	Rather brighter than *n* — what might be classed as two tenths. Distinctly brighter than *a*.
	Feb. 22.	Equal to *n*.
	Mar. 13.	Dimmer than *a*, but brighter than *g* of 10th mag., and equal to *p* of 9.4 mag.

R Ursæ Majoris.

The maxima of this star vary from 6 to 8.2 magnitude. The recent maximum was due on February 8th.

1902.	Jan. 31.	Equal to *h*, but not to *g*, which seems slightly brighter. Both comparison-stars are classed as of 8th mag.
	Feb. 2.	Ditto.
	Mar. 12.	Ditto.
	Mar. 14.	Decreased to *n* of 9th mag.
	Mar. 24.	It is of about 10.3 mag.

L^2 *Puppis.*

The maximum of this star was due February 28th.

1902.	Jan. 31.	Brighter than 4th mag., as compared with *Sigma Puppis* of 3.4 and L^1 of 5th mag.
	Feb. 12. Mar. 2, 9.	Ditto.
	Mar. 14.	Slightly brighter than *b Puppis*. Classed as of 4.8 mag

San Francisco, March 31, 1902.

KAPTEYN'S CONTRIBUTIONS TO OUR KNOWLEDGE OF THE STARS.

By J. D. Galloway.

In commenting on the award of the gold medal of the Royal Astronomical Society to Professor J. C. Kapteyn for his work in connection with the Cape Photographic *Durchmusterung* and his researches on stellar distribution and parallax, Dr. Glaisher, the president of the society, gave a brief history of this great photographic catalogue, and referred to some of KAPTEYN's other contributions to stellar cosmography.

The idea of making a photographic star-map was suggested to GILL when experimenting with an ordinary camera in photographing the great comet of 1882. The work for the catalogue was done with a Dallmeyer rapid rectilinear lens of six inches aperture and fifty-four inches focus. Another lens was tried for a time, but found unsatisfactory, and all plates taken with it were discarded; so that the finished work is the product of one lens. Part of the expense was borne by the Government Grant Fund of the Royal Society, part by the Dutch Government, and part by several Dutch institutions. One reason for the withdrawal of the Royal Society from the work was the commencement, in 1887, of the preparation of the International Astrographic Chart. It was thought by some that this would supersede the work of GILL and KAPTEYN; but the belief of Dr. GILL was that there was an immediate use for his work, so it was pressed to a conclusion.

KAPTEYN offered his services to GILL in 1885, stating that he believed he had "enthusiasm for the matter equal to six or seven years of such work." He did not overestimate his enthusiasm, which was to sustain him not only for six or seven years, but for nearly thirteen. KAPTEYN's proposal was that he be allowed to measure the plates taken at the Cape and to tabulate the results. The actual photographing of plates at the Cape began in April, 1885, and was completed at the end of 1890.

The principal object which GILL had in view may be briefly described as the extension of the Bonn *Durchmusterung* to the south pole. To determine the exposure necessary for this purpose, an area in the Bonn *Durchmusterung* was selected and photographed. The negative was then compared star by star with ARGELANDER's chart, and the duration of the trial exposures was gradually increased till it was certain that every star in the selected part of the chart was shown as a measurable disc on the plate photographed from the sky. It may be mentioned that when the negative from the sky showed nearly the whole of ARGELANDER's stars, it also showed a great many more, as the Bonn *Durchmusterung* professes to complete only as far as stars of the 9.2 magnitude. Every area was photographed on two different nights, in order to avoid the possibility of a speck on the plate being mistaken for a star.

KAPTEYN'S work was done at Groningen, Holland, and consisted in the measurements of the stars on the plates, their reductions, and the forming of the catalogue. All the measurements for the catalogue were made by an instrument designed by KAPTEYN for the purpose. The principle of this instrument, the object of which was to measure spherical coördinates from the plate, occurred to him very soon after he had received the first plates. It depends upon the obvious fact that by placing a plate at the proper distance (that is, at the focal distance of the photographic telescope), with the film farthest from the eye, it is possible to cover the stars in the sky with their corresponding images. If, therefore, we substitute for the eye an instrument by which spherical coördinates can be measured in the sky, we can measure these coördinates as well on the plate. Various refinements were used. The work was done in a darkened room by two observers and a clerk. Two plates covering the same region were fixed in the holder, and by adjustment were so placed that the image of a star on one plate nearly covered the image of the same star on the other plate. True stars then appeared double, while accidental specks appeared single, and could at once be distinguished.

Each plate was observed twice, and as soon as the second observation was made the results were compared and discrepancies examined. The second observations and examinations were invariably made by KAPTEYN.

The diameters of the images of the stars were estimated to 2″ of arc, and from these diameters the magnitudes of the stars were determined by an empirical formula.

The work is published in three volumes, bearing dates of 1896, 1897, and 1900. It includes all stars down to about 9.5 magnitude from —18° to the south pole. The number of stars included is 454,857. The catalogues of ARGELANDER and SCHÖNFELD together contain 431,760 stars for the rest of the sky, the average number per square degree being for the Cape, Argelander and Schönfeld catalogues 32.66, 15.19, and 18.21, respectively, so that the star-density of the Cape catalogue is more than double that of ARGELANDER'S.

As compared with the catalogue of SCHÖNFELD, the star density shown by the Cape catalogue varies widely, some regions containing three times the number of stars given by SCHÖNFELD in the same area, while in some regions the latter's catalogue was the richer, containing almost double the number shown on the plates. KAPTEYN also found that, corresponding to these variations in the star-brightness, equal diameters on the plates were produced by stars of unequal brightness in different parts of the sky. THOME suggested that this might be due to a tendency on the part of a visual observer to overlook faint stars in a rich field; but KAPTEYN considers any such explanation quite inadequate, and he concludes that the difference between the visual and the photographic magnitudes is largely due to the positions of the stars with regard to the Milky Way, and that, even if we take into account only stars of the same spectral type, those in the Milky Way are in general bluer than the stars in other regions of the sky.

In 1889 KAPTEYN proposed a comprehensive method of determining stellar parallax, having been engaged in that work when he made his proposal to GILL in 1885. His plan was to expose the plates for the astrographic catalogue at three successive epochs of maximum parallactic displacement, the plates being carefully preserved in the intervals of six months, and developed after the third exposure. The plates would then furnish, in addition to the position of the stars, a first determination of their parallaxes. The proposal was not adopted for the great catalogue, but Professor DONNER obtained a series of plates at Helsingfors which were measured by KAPTEYN and the approximate determinations of the parallaxes of 246 stars were made.

Since the direct determination of stellar parallax has not given results on anything like the scale required for the purpose of judging of the relative distances of the stars, we are compelled to resort for data on this point to the parallactic displacement caused by the motion of the solar system in space. This parallactic motion, however, cannot be separated from the real proper motion for the individual stars, but there is every reason to think that the real proper motion shows but little preference for determinate directions, and it may therefore be assumed that, in the mean results obtained from small groups of stars, these real proper motions will destroy each other, leaving only that part due to solar motion. It is this parallactic displacement that gives the most reliable measure of the mean distances of stars. KAPTEYN has undertaken the resolution of the proper motions of 2,357 stars into components in the apical direction (that is, the direction of the Sun's movement in space), and normal thereto. These stars are in the Draper catalogue of spectra, and are also included in the Bradley-Auwers catalogue of Right Ascensions and Declinations. The stars were taken from the Draper catalogue, because KAPTEYN had decided to divide them into groups according to their spectral type, and to consider the groups separately. This division has shown that stars with small proper motions belong generally to the first type, and those with large proper motions to the second, to which type our own Sun belongs. It may be that the stars of the second type are moving faster than those of the first, but it seems more probable that they are less distant. This gives some support to GOULD's suggestion that the Sun is a member of a star-cluster.

Other important papers of KAPTEYN refer to the distribution of cosmical velocities, the distribution of stars in space, the statistical relations between parallax, proper motion, and magnitude, and upon the luminosity of stars. He has deduced the position of the solar apex by a new method, in which the apex is so chosen that the sum of the proper motions resolved in the direction of the Sun's apex is a maximum, or that the sum of the motions perpendicular to this direction is zero. The resulting apex is $\alpha = 273^\circ.6$, $\delta = 29^\circ.5$ as deduced from 2,640 Bradley stars and 699 Porter stars. The discrepancy from PORTER's results (obtained by KAPTEYN's method), $\alpha = 280^\circ.5$, $\delta = 49^\circ.3$, and from CAMPBELL's result, $\alpha = 277^\circ.5$, $\delta = 20^\circ.0$, derived from spectroscopic determinations of 280 velocities in the line of sight, only shows what might have been expected—that considerable groups of stars in different parts of the sky are affected by common drift which is quite distinct from parallactic motion.

As showing the estimation in which KAPTEYN's work is held, the following is added from NEWCOMB, when writing of the Cape *Durchmusterung:* "This work of KAPTEYN offers a remarkable example of the spirit which animates the born investigator of the heavens. . . . The years of toil devoted to it were, as the writer understands, expended without other compensation than the consciousness of making a noble contribution to knowledge, and the appreciation of his fellow astronomers of this and future generations."

PLANETARY PHENOMENA FOR JULY AND AUGUST, 1902.

By Malcolm McNeill.

July.

The Earth is in aphelion July 4th, 5 A. M. Pacific Time.

Mercury is a morning star, having passed inferior conjunction on June 23d. It reaches greatest west elongation on July 15th, and is well on toward superior conjunction by the end of the month. The conditions for visibility are not very good; but after the first week of the month the planet rises an hour or more before sunrise, and there is a possibility of seeing it in the morning twilight if the air is very clear.

Venus is the chief morning star, and throughout the month rises about two and one-half hours before the Sun. It moves about 35° eastward during the month from a position between the *Pleiades* and *Hyades* in *Taurus* to the middle of the constellation *Gemini,* west and south of *Castor and Pollux.* Its distance from the Sun diminishes about 5°.

Mars is also in the morning sky, but has not begun to brighten up very much. It moves about 20° eastward from the eastern part of *Taurus* into *Gemini,* and toward the close of the month is near *Venus,* a little to the north of the latter.

Jupiter will, at the end of the month, rise a little after sunset, and is therefore in fair position for late evening observation. It is in the eastern part of the constellation *Capricorn,* and is moving westward, the motion being about 3° during the month, and on a line a little south of the line of motion during the spring months.

Saturn comes to opposition with the Sun on July 17th, and is therefore above the horizon practically the entire night, during the month. It is in the western part of the constellation

Capricorn, and it moves a little more than 2° westward. It draws a little nearer *Jupiter,* but hardly enough to be noticeable without measurement. As seen in the telescope, the apparent minor axis of the rings will be much shorter than it was in 1901.

Uranus remains above the horizon until early morning. It moves about 1° westward in the constellation *Ophiuchus* and is, on July 1st, 1½° west and about 2° north of *θ Ophiuchi,* a third-magnitude star in the southern part of the constellation.

Neptune is very close to the Sun, a morning star, having passed conjunction on June 23d.

AUGUST.

Mercury is a morning star at the beginning of the month, rising about an hour before sunrise, but it rapidly nears the Sun and passes superior conjunction on August 11th, becoming an evening star. By the end of the month it has moved far enough away from the Sun to set nearly an hour and a half later; and it can therefore be seen in the evening twilight if the air is clear.

Venus is drawing nearer the Sun, and the time between the rising of the planet and that of the Sun shortens up nearly half an hour. The planet moves about 36° eastward from *Gemini* into *Cancer,* and lessens its distance from the Sun about 8° during the month.

Mars is increasing its apparent distance from the Sun, and by the end of the month rises at about 2 A. M. It moves eastward about 20° in the constellation *Gemini* and during the latter part of the month is south of the principal stars *Castor* and *Pollux,* at about the same distance from the nearer as the stars are from each other. The planet will not be very bright, but can readily be distinguished by its ruddy color. On August 1st *Mars* is in conjunction with *Venus.*

Jupiter comes to opposition on August 5th, and is therefore above the horizon practically the entire night. It is still in *Capricorn* and moves westward rather more than 3°.

Saturn is above the horizon until long after midnight. It is in the western part of *Capricorn* and moves westward about 2°. It approaches *Jupiter* about 2° during the month, their distance apart at the close of the month being about 18°.

Uranus is in the western sky in the evening, but is high enough for convenient observation until quite late. It changes its position only a little during the month, and it may still be found by its nearness to *θ Ophiuchi*. The planet is about a degree farther west of the star than it was on July 1st.

Neptune is farther away from the Sun than during July, but needs a telescope to show it.

JULY–AUGUST, 1902.

PHASES OF THE MOON, P. S. T.

New Moon . . .	July 5,	4^h 59^m A.M.
First Quarter . . .	July 12,	4 47
Full Moon . . .	July 20,	8 45
Last Quarter . . .	July 27,	9 15 P.M.
New Moon . . .	Aug. 3,	12 17
First Quarter . . .	Aug. 10,	8 24
Full Moon . . .	Aug. 18,	10 3
Last Quarter . .	Aug. 26,	3 4 A.M.

THE SUN.

1902.	R. A.	Declination.	Rises.	Transits.	Sets.
July 1,	6^h 38^m	+23° 10′	4^h 39^m A.M.	12^h 3^m P.M.	7^h 27^m P.M.
11,	7 19	+22 12	4 45	12 5	7 25
21,	7 59	+20 37	4 53	12 6	7 19
31,	8 39	+18 27	5 1	12 6	7 11
Aug. 10,	9 17	+15 47	5 10	12 5	7 0
20,	9 55	+12 41	5 19	12 3	6 47
30,	10 32	+ 9 15	5 29	12 1	6 33

MERCURY.

July 1,	5 20	+18 44	4 5 A.M.	11 16 A.M.	6 22 P.M.
11,	5 55	+19 52	3 30	10 41	5 52
21,	6 36	+21 50	3 24	10 43	6 2
31,	7 49	+21 49	3 58	11 16	6 34
Aug. 10,	9 15	+17 47	5 1	12 3 P.M.	7 5
20,	10 31	+10 58	6 1	12 39	7 15
30,	11 34	+ 3 24	6 52	1 3	7 14

VENUS.

July 1,	3 59	+18 38	2 19 A.M.	9 24 A.M.	4 29 P.M.
11,	4 48	+20 46	2 20	9 34	4 48
21,	5 38	+22 9	2 26	9 45	5 4
31,	6 29	+22 32	2 36	9 57	5 18
Aug. 10,	7 21	+21 53	2 50	10 9	5 28
20,	8 13	+20 11	3 10	10 21	5 32
30,	9 3	+17 31	3 31	10 32	5 33

Mars.

July 1,	5 3	+23 4	3 6 A.M.	10 29 A.M.	5 52 P.M.
11,	5 33	+23 41	2 53	10 19	5 45
21,	6 2	+23 56	2 41	10 9	5 37
31,	6 32	+23 51	2 32	9 59	5 26
Aug. 10,	7 0	+23 26	2 23	9 48	5 13
20,	7 28	+22 43	2 15	9 37	4 59
30,	7 56	+21 43	2 7	9 25	4 43

Jupiter.

July 1,	21 16	−16 43	9 41 P.M.	2 43 A.M.	7 45 A.M.
Aug. 1,	21 2	−17 48	7 30	12 28	5 26
Sept. 1,	20 47	−18 52	5 13	10 6 P.M.	2 59

Saturn.

July 1,	19 51	−21 4	8 33 P.M.	1 18 A.M.	6 3 A.M.
Aug. 1,	19 41	−21 31	6 20	11 3 P.M.	3 46
Sept. 1,	19 34	−21 51	4 12	8 53	1 34

Uranus.

July 1,	17 10	−23 2	5 56 A.M.	10 33 P.M.	3 10 A.M.
Aug. 1,	17 6	−22 57	3 51	8 28	1 5
Sept. 1,	17 5	−22 56	1 48	6 25	11 2 P.M.

Neptune.

July 1,	6 6	+22 21	4 11 A.M.	11 32 A.M.	6 53 P.M.
Aug. 1,	6 11	+22 20	2 14	9 35	4 56
Sept. 1,	6 15	+22 18	12 15	7 36	2 57

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off left-hand limb before August 5, off right-hand limb afterward, as seen in an inverting telescope.)

I, D,	July 1,	1^h 40^m A.M.
I, D,	2,	8 9 P.M.
II, D,	3,	8 26
I, D,	8,	3 34 A.M.
I, D,	9,	10 3 P.M.
II, D,	10,	11 0
III, D,	14,	9 17
I, D,	16,	11 57
II, D,	18,	1 35 A.M.
I, D,	18,	6 26 P.M.
III, D,	21,	1 17 A.M.
I, D,	24,	1 52
II, D,	25,	4 10
I, D,	25,	8 21 P.M.
II, D,	28,	5 27
I, D,	31,	3 47 A.M.
I, D,	Aug. 1,	10^h 15^m P.M.
I, D,	3,	4 44
I, R,	9,	2 26 A.M.
I, R.	10,	8 55 P.M.
II, R,	12,	1 29 A.M.
III, R,	12,	4 51 P.M.
I, R,	17,	10 50
I, R,	19,	5 18
III, R,	19,	8 51
II, R,	22,	5 22
I, R,	25,	12 45 A.M.
I, R,	26,	7 13 P.M.
III, R,	27,	12 53 A.M.
IV, D,	29,	6 0 P.M.
II, R,	29,	7 58
IV, R,	29,	10 43

TWO RECENT VOLUMES OF DOUBLE-STAR MEASURES.*

A REVIEW, BY R. G. AITKEN.

We have several times called attention in these *Publications* to the fact that the progress of double-star astronomy in the last few years has been very satisfactory; the well-known binary stars have been followed more carefully than ever before, and their orbits revised and corrected by means of the new measures; old and neglected pairs have been looked up and measured; many new pairs have been discovered; and two of the most important catalogues of double stars—BURNHAM'S and OTTO STRUVE'S†—have been published in such form as to put all data relating to the stars they contain in convenient form for study.

But the field is large and the toilers in it even now none too many. Especially do we need all the measures we can get of the closer double stars—those that require large telescopes for their accurate measurement. Such contributions as the two volumes now under consideration are for this reason particularly welcome.

The first one contains the observations of 900 double stars made by Mr. ERIC DOOLITTLE with the new 18-inch telescope of the Flower Observatory, between the dates of January 1, 1897, and October 15, 1900. His observing list comprised "348 β stars, principally those which have not been measured since 1891, or of which, for other reasons, the character of the motion is uncertain; 471 miscellaneous stars, principally neglected pairs of the HERSCHELS and STRUVES, and including those (22) which are believed to be new; 55 stars noted as double in the catalogues of the *A. G.* Zones, 55°–70°, and previously measured by BURNHAM; and 33 stars of the 40 binary stars whose orbits have been computed by Dr. SEE."

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* *Publications of the University of Pennsylvania*, Astronomical Series, Vol. I, Part III. Measures of nine hundred Double and Multiple Stars, made with the Eighteen-inch Refractor of the Flower Astronomical Observatory, by ERIC DOOLITTLE.

Publications de Poulkovo, Série II, Vol. XII. Mikrometer-Messungen von Doppelsternen ausgeführt am 30-zölligen Refractor zu Pulkowa von HERMANN STRUVE.

† By W. J. HUSSEY, as Vol. V, *Publications* of the Lick Observatory.

The fact that Mr. DOOLITTLE in selecting his list of stars had the benefit of advice from Mr. BURNHAM, to whose kindness all of the younger double-star observers owe so much, is in itself sufficient evidence that the work was worth doing; and a study of the measures shows that the work was well done. In general, each star was measured on at least three nights, the more rapid binaries in some cases on as many as fifteen or twenty nights, and great care was exercised to make the separate settings independent and to free the measures as far as possible from systematic errors. The results have been printed in very convenient and neat form, giving the observed data without any superfluous matter.

Professor STRUVE'S volume contains the results of the observations made by him in the period 1885–1895 with the 30-inch telescope at Pulkowa. His working-list during the first year was made up of β stars, which were too difficult for observation with the 15-inch refractor. To those were added in the following year all the Struve and Otto Struve stars which, according to the measures by STRUVE, OTTO STRUVE, and DEMBOWSKI, had given evidence of motion, and also a few other interesting stars. This brought the total number of stars to about 900,—470 Σ stars, 190 OΣ stars, 200 β stars, and 30 miscellaneous pairs. As the telescope was also used for extensive series of satellite measures and for spectroscopic work, the work on this double-star programme was so much interrupted that when Professor STRUVE left Pulkowa in 1895 measures had been made of but 750 of these pairs. Special attention had been given, however, to the closer pairs and those in rapid motion,—as for example, ζ *Cancri*, ε *Hydræ*, ζ *Herculis*, and δ *Equulei*,—and in all about 3,100 separate measures were made.

Professor STRUVE devotes the greater part of his introduction to this volume to the discussion of the systematic errors of his observations.

In measuring the angle of pairs separated by 5″ or more, he followed the method of bisecting both stars with a single wire; but the position-angles of the closer pairs were measured by the "usual method,"—that is, by placing the stars midway between two wires slightly separated.

Four settings were generally made, the eyes being kept parallel or perpendicular to the line joining the stars. Double distances were measured, four settings being made ordinarily.

To determine the systematic errors directly, many of the stars were measured repeatedly at different hour-angles and with eyes parallel and perpendicular to the line joining the stars, and measures with a very high power were also compared with those made with the lower-power eye-piece, which was more generally used.

Professor STRUVE concludes that his observations in angle are affected by small systematic errors, which, in the case of angles measured by the "usual method," vary with the hour-angle and the position of the eyes. The position of the fainter star, to the right or left, above or below the primary, also exercises an appreciable effect. The measures made by the method of bisection do not seem to be affected by the hour-angle nor by the position of the eyes. But while the systematic errors seem to be real, they are in all cases small, the final result being that his angle-measures require an average correction of + 0°.42.

This direct investigation is confirmed by comparisons with the measures of W. STRUVE and DEMBOWSKI, which lead to an average correction of + 0°.38.

The comparison of his distance-measures with those of these two observers indicates that his own are practically free from systematic errors.

Professor STRUVE also gives an interesting comparison of his measures of twenty-seven binary stars with the computed positions derived from Dr. SEE's orbits. The table shows the observed positions, the residuals HΣ — computed, and also the residuals (O – C) given by Dr. SEE for the corresponding dates. Dr. STRUVE, for reasons that are readily apparent, does not use this material to determine his systematic errors definitely. But it occurred to me in examining the table that corroborative testimony could be drawn from it by comparing the two columns of residuals. This would give residuals HΣ — O where O indicates the mean of the observed positions as combined by Dr. SEE for the basis of his computations. Assuming these means to be free from systematic error (an assumption not wholly warranted) the residuals will give H. STRUVE's systematic errors. I have made this comparison, and find that the average residual in angle (omitting two abnormal residuals of + 13°.6 and + 16°.4, respectively) is — 0°.32, and in distance + 0″.028. The systematic corrections are therefore + 0°.32 and — 0″.028, results which, so far as their evidence goes, confirm the observer's own conclusions.

Professor STRUVE has also investigated the probable error of his measures dividing the stars into classes according to the measured distances. He finds that the maximum probable error is less than ± 0″.09 in either coördinate,—a result that is very satisfactory.

It is evident from these investigations that the measures possess a high degree of accuracy.

It may perhaps be noted as a matter of some practical interest that both DOOLITTLE and STRUVE differ from the present observers at the Lick Observatory (and, I believe, from BURNHAM and BARNARD also) in their method of measuring the angles of "stars not very far apart." They place the stars midway between two wires separated by a few seconds of arc; we use the method of bisection with a single wire.*

The former method is the one used by practically all the earlier double-star observers, and by many excellent observers at the present time as well; but I am satisfied that better results, —that is, results more likely to be free from systematic error,— are attainable by the latter method, especially if the use of the tangent-screw is dispensed with and the settings are made with the pinion, the wire being moved quickly to either side of the true position a number of times before final adjustment.

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*See Professor HUSSEY's statement, which represents my observing practice as well, in *Publications* Lick Observatory, Vol. V, p. 13.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

THE GREAT SOUTHERN COMET OF 1901.

Shortly before the total eclipse of 1901, May 18th, a very bright comet appeared in the southern sky, being discovered almost simultaneously at a number of places. The first reported sight of it in Sumatra was on May 3d, by Mr. W. W. DINWIDDIE, of the U. S. Naval Observatory expedition at Solok. It was then near the Sun in the evening sky, but very bright and conspicuous even in bright twilight.

The comet was not seen in Padang until the evening of May 5th. It was then brilliant, with a tail 6° or 8° in length, although it is said to have lost much of its light in the interval of two days.

On May 6th, the Pierson-Dallmeyer camera for use at the eclipse was temporarily mounted, and on the same evening four exposures were made. The longest exposure was seven minutes, and recorded the tail to a distance of 4°.

The accompanying illustration is from the second negative obtained, with an exposure of three minutes, and is enlarged two diameters. The tail on this plate is shown to a distance of 3½°, and a second very faint streamer is to be seen to the south, making an angle of about 35° with the principal tail. The principal tail appears to be of the hollow cylindrical type usually seen in the case of large comets, especially those making a near approach to the Sun.

The nucleus of the comet and the star-images are seen elongated, owing to the lack of means to correct for the varying refraction and the irregularities of the driving clock.

C. D. PERRINE.

MT. HAMILTON, CALIFORNIA, 1902, May 15.

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* Lick Astronomical Department of the University of California.

NOTE ON COMET BROOKS.

The telegram announcing the discovery of a comet by Dr. W. R. BROOKS was received here on the morning of April 16th. It was observed the following morning (Thursday) with the 12-inch telescope, and was found to be a rather bright telescopic object. By comparison with neighboring stars, its light was estimated as about equal to that of a star of 8.5 magnitude. A straight tail could be traced fully half a degree, in position-angle 295°.5 (April 16 at $16^h\ 5^m$, Mt. Hamilton M. T.) or directly away from the Sun. The condensation in the head of the comet was well defined, but there was no stellar nucleus.

On the following morning the sky was cloudy, but the comet was seen twice at intervals of nearly five minutes, and each time for only a few seconds. Advantage was taken of these glimpses to make one setting each in R. A. and Decl. Owing to continued bad weather, the comet has not been seen here since. As the comet was rapidly approaching the Sun, and as no observations were received here for dates later than April 16th, I used the Koenigsberg and Mt. Hamilton observations of that date (the time interval between them being about 10½ hours) and the incomplete observations of the 17th to derive an approximate set of elements, with the following result:—

$$
\begin{aligned}
T &= \text{May } 6.82 \\
\omega &= 226^\circ\ 13' \\
\Omega &= 51\ \ 31 \\
i &= 68\ \ 18 \\
\text{Natural } q &= 0.4643.
\end{aligned}
$$

Because of the uncertainty of the third observation, these elements were considered as merely a rough approximation, but it will be seen that they are in close agreement with those cabled later on from Kiel,* which were based on observations made in Europe on April 16th, 17th, and 18th. They show that the comet will not be visible to observers in the northern hemisphere for several months. By that time it will be so far from the Earth and Sun that it is very doubtful whether it will be bright enough to be seen. It is to be hoped that observers in the southern hemisphere have been more fortunate in securing measures of this comet than those in Europe and America.

May 14, 1902. R. G. AITKEN.

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* See Astronomical telegrams, on another page of this number.

MEASURES OF THE COMPANION OF *SIRIUS*.

During the present season I have obtained the following measures of the companion of *Sirius* with the thirty-six-inch refractor:—

1901.853	129°.2	5″.30
1902.237	127 .8	5 .32
.239	127 .6	5 .57
.241	126 .3	5 .58
.252	126 .4	5 .49
.255	125 .2	5 .48
1902.18	127°.1	5″.46

The interpolated place of the companion for the mean date from ZWIERS's ephemeris is 125°.3, 5″.48.

W. H. HUSSEY.

MEASURES OF THE COMPANION TO *SIRIUS*.

The following measures of the companion to *Sirius* were made with the 36-inch telescope, using an eye-piece with a power of 520. The observing conditions were most favorable on the second night. On the last night the seeing was poor, and measures were made with difficulty:—

	θ	ρ	Sid. Time.
1902.238	127°.5	5″.50	8^h.0
.241	126 .0	5 .46	7 .0
.252	129 .5	5 .51	8 .3
1902.24	127°.7	5″.49	

ZWIERS's orbit gives the position for 1902.24 as 124°.8, 5″.51.

May 15, 1902. R. G. AITKEN.

PERSONAL NOTES.

Dr. W. W. CAMPBELL, Director of the Lick Observatory, was elected to membership in the National Academy of Sciences at the last annual meeting, held in Washington, D. C., on April 17th.

Dr. S. D. TOWNLEY, of the Astronomical Department at Berkeley, will spend the summer vacation at the Lick Observatory, devoting his time to the observation of variable stars and to other photometric work.

ASTRONOMICAL TELEGRAMS.

(Translations.)

CAMBRIDGE, MASS., April 16, 1902.

To Lick Observatory. (Received 11:00 A. M.)

BROOKS telegraphs that he has confirmed his discovery of a comet on April 14th; its position at 16^h (Eastern Standard Time), April 15th, was R. A. $23^h\ 8^m\ 10^s$; Decl. $+27° 25'$; its daily motion 12^m east and 2° south; brightish, with tail.

(Signed) E. C. PICKERING.

MT. HAMILTON, CAL., April 17, 1902.

To Harvard College Observatory. (Sent 9:30 A. M.)

To Students' Observatory, Berkeley.

Comet Brooks was observed by AITKEN on April 16.9946 G. M. T. in R. A. $23^h\ 21^m\ 7^s.7$; Decl. $+ 25° 12' 25''$.

(Signed) W. W. CAMPBELL.

CAMBRIDGE, MASS., April 17, 1902.

To Lick Observatory. (Received 1:00 P. M.)

Kiel cables that Comet Brooks was observed by POSTELMANN at Koenigsberg on April 16.5521 G. M. T. in R. A. $23^h\ 15^m\ 41^s.1$; Decl. $+ 26° 6' 35''$.

(Signed) E. C. PICKERING.

BOSTON, MASS., April 27, 1902.

To Lick Observatory. (Received 10:00 A. M., April 28.)

Elements and ephemeris* of Comet 1902 *a* have been cabled from Kiel as follows:—

$T =$ May 7:12, G. M. T.
$\omega = 228° 23'$
$\Omega = 52\ \ 15$
$i = 66\ \ 30$
Natural $q = 0.4512$.

(Signed) J. RITCHIE, JR.

To Dr. CAMPBELL, BERKELEY, CAL., May 2, 1902.
Lick Observatory. (Received 11:20 A. M.)

Elliptic elements† and ephemeris* of Comet 1902 *a* were computed by STEBBINS, CURTISS, WEYMOUTH, and LEUSCHNER as follows:—

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* The ephemeris at four-day intervals is here omitted.

† According to a later message, these elements are referred to the Equator—not the Ecliptic.

T = May 28.39, G. M. T.
$\omega = 274° 30'$
$\Omega = 35 \quad 3$
$i = 71 \quad 50$
Natural $q = 0.5542$
$e = 0.3947$
Period = 0.88 years.

This is a rough approximation. The orbit indicates probable identity of this comet with Comet 1748 II.

(Signed) A. O. LEUSCHNER.

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in the work of this department. Communications to this end may be sent to FRANK SCHLESINGER, International Latitude Observatory, Ukiah, California.

During 1901 there were discovered thirty-six minor planets, all by photography, and all but one by the astronomers at Heidelberg, Germany. The thirty-sixth, discovered at Arequipa, is an unusually interesting one, its orbit having a large inclination to the ecliptic and having the greatest eccentricity (0.38) of any known minor planet. When discovered the planet was within 29° of the south pole.

Dr. BAUSCHINGER, Director of the Berlin Rechen-Institut, has published a table of statistics of the minor planets discovered up to the end of 1900, which completes the first century of our knowledge of them. The ascending nodes show a decided tendency to cluster in the neighborhood of the ascending node of *Jupiter's* orbit which is in satisfactory agreement with NEWCOMB'S theoretical results. There seems to be a slight tendency for great inclinations and great eccentricities to go together; but there is no connection between eccentricity and mean distance. Of the inclinations 315 are under 10°, 133 are between 10° and 20°, 29 between 20° and 30°, and one (*Pallas*) over 30°.

Arranging the planets in the order of mean daily motions, the gaps near 900" and 600" (that is, three times and twice *Jupiter's* mean daily motion) are very strongly marked. There are other less strongly marked gaps. The minor planets may accordingly be divided into three groups:—

The *Mars* Group, with mean daily motions between 2,015" and 900"
The *Chief* Group, " " " " 900" " 600"
The *Jupiter* Group, " " " " 600" " 400"

These groups number respectively 108, 337, and 18 planets.

Dr. BAUSCHINGER expresses the opinion that very few minor planets brighter than the tenth magnitude remain to be discovered, but that the fainter ones show no signs of exhaustion.

A formula is given for determining the diameters of asteroids, the mean albedo (that is, the reflecting power per unit of surface) being assumed as 0.24, midway between those of *Mars* and *Mercury*. It goes without saying that no stress can be laid upon individual diameters deduced by this method, especially since we know from Professor BARNARD's measures on the four brightest asteroids that their albedoes vary greatly. Following are the results of Professor BARNARD and Dr. BAUSCHINGER for these four planets:—

	Diameter in Miles.		Albedo.	
	BAUSCHINGER.	BARNARD.	BAUSCHINGER.	BARNARD.
Ceres	482	477	0.240	0.195
Pallas	364	304	0.240	0.257
Juno	182	120	0.240	0.488
Vesta	518	239	0.240	0.825

BAUSCHINGER's diameter for *Eros* is 32 kilometers, or 20 miles. It would be 15 miles if the mean of BARNARD's albedoes (0.44) were used.

The volumes of the twelve largest planets (Nos. 1, 2, 3, 4, 7, 9, 10, 15, 16, 22, 29, 349) form two thirds of the volume of all the known minor planets; and since the tiny planets now discovered add so little to the volume, Dr. BAUSCHINGER estimates that the entire family (including those to be discovered) would form a sphere of diameter 1,320 kilometers, or 830 miles. If the albedo 0.44 were used, this diameter would be reduced to 610 miles, or one thirteenth of the Earth's; the corresponding mass is one thirty-three-hundredths of the Earth's, or one fortieth of the Moon's.

Such estimates are apt to be fallacious; for there may be numerous planets of considerable relative mass near *Jupiter's* orbit which are faint, owing to their great distances from the Earth.

Only two new comets were observed in 1901. GIACOBINI's comet, discovered on December 20, 1900, was but little observed, owing to its extreme faintness. It was observed by AITKEN on February 15th, with the 36-inch refractor, but this is an isolated position, as other measures ceased a month earlier. Dr. KREUTZ's short-period ellipse represented the motion of the comet in February, but no further inquiry into the orbit has been made.

The brightest comet of the last twenty years was independently seen at several places in the southern hemisphere, being reported as early as April 12th, at Paysandu. The most northerly station at which it was observed is the Lick Observatory, but the orbit rests entirely on measures taken in the southern hemisphere. It moved through the constellations *Pisces, Eridanus,* and *Orion,* nearly parallel with the equator. Mr. MERFIELD, employing three normal places, extending from May 6th to June 6th, derived a very much elongated ellipse, but he appears to prefer a parabolic motion. This comet attracted considerable attention, as the nucleus on May 2d rivaled *Sirius* in luster, being decidedly elliptical in shape, while the tail had in it a dark rift, which gave it a bifurcated appearance.

The only other comet besides these two that has been under observation is that of ENCKE. The preparation of the ephemeris to assist its recovery was undertaken by Dr. THORNBERG of the Kronstadt Observatory, and the comet was found by Professor WILSON, of Northfield, Minn., on August 5th, very near the predicted place.

Two comets passed through perihelion without being seen, although looked for. J. D. G.

CHANDLER'S researches on the Variations of Latitude have led him to many collateral discoveries of the greatest interest. The most recent of these is his vindication of the *Reflex Zenith-Tube.* This instrument was designed and erected at Greenwich by AIRY, late Astronomer Royal for England. It is capable of measuring with great accuracy the zenith-distance of a star at its culmination, providing that this zenith-distance is not more than a few minutes of arc. If the star is bright enough to be observed during the daytime, and if the observations extend over several years, it is possible thus to determine the numerical values of aberration, nutation, and the star's absolute parallax. Such a series of observations was carried out by AIRY upon the star γ *Draconis,* but with most unsatisfactory results. The observations gave a large negative parallax for the star—manifestly impossible to be real—and a value for the aberration so small as to be out of the question. AIRY sought in vain to find the cause of these discrepancies in the instrument, and finally discontinued the observations with great disappointment in 1882. A few observations (about 300) were made with the instrument by the present administration of the observatory between 1886 and 1899, for the purpose of detecting if possible the cause of the anomalies, but again without satisfactory results. CHANDLER has just shown that when the variation of latitude (a phenomenon unthought of in AIRY's day) is taken into account, things become completely accounted for, and that the instrument has done a greater service for astronomy than even its builder thought it would do; for the observations made with it enable us to compute the variation of latitude during an early period (1857-1870). Since CHANDLER'S investigation has been published Mr. CHRISTIE, the present Astronomer Royal, has stated that the Reflex Zenith-Tube will again be put into service.

Professor W. H. PICKERING calls attention in the Monthly Notices of the Royal Astronomical Society to what he names the "green flash" at sunset. He has noticed several times that for a second or so, at the final disappearance of the Sun's upper limb below the horizon, a distinctly green color is seen. This he accounts for as a subjective phenomenon, or illusion, similar to the complementary color which one sees after gazing intently at a bright surface; as the edge of the Sun looks red at sunset, its withdrawal will leave upon the eye the impression of green. This explanation of PICKERING'S is, however, shown not to be the true one by several observers who have reported it at *sunrise,* just before the edge of the Sun makes its appearance. Lord KELVIN reported this phenomenon as seen at sunrise in the Alps three years ago, and Professor NIJLAND of Utrecht, Holland, has lately seen it several times at sea. No satisfactory explanation has yet been offered. Valuable observations of the "green flash" can be made by any amateur who has access to a site from which the Sun appears to rise or set in the true horizon. Observations may be made with the naked eye, though a small telescope or opera-glasses will be found advantageous. The observer should record failures to see the phenomenon and the general conditions of the sky, the temperature, etc., every time he looks for it.

The General Notes of the last number of these *Publications* contain a notice of KAPTEYN'S brilliant suggestion as to the nature of the nebulous light surrounding *Nova Persei.* This theory has received some confirmation since then, and, on the other hand, some contrary evidence has been adduced. The investigations of its parallax indicate on the whole that the

Nova is at the great distance demanded by KAPTEYN'S theory. Even more strongly in its favor is the fact pointed out by Mr. RITCHEY, that the appearance of new patches of nebulous light upon the photographs is just what we should expect if we are seeing different sections of dark matter successively lit up by the light of the *Nova.* If what we see were matter flying from the *Nova* with enormous velocities we should expect a certain degree of persistence of form. On the other hand, a telegram from the Lick Observatory announces that PERRINE could find no trace of polarization (the inevitable accompaniment of reflection) in the light of the nebula. For the present we may feel reasonably sure that we have to do with either such a condition as KAPTEYN supposes, or else, as WOLF suggested, with an electrical wave originating in the *Nova.* Still another theory has been advanced, similar to ARRHENIUS'S explanation of comet-tails,—namely, that the nebula is being driven from the *Nova* by light-pressure. It would appear that this last theory must be abandoned, as there would result from it an ever-increasing velocity in the expanding nebula; whereas uniform velocity is the observed fact.

Professor E. C. PICKERING announces the receipt of an unconditional gift of $20,000 to the Harvard Observatory by a friend whose name is not made public. Professor PICKERING states that he intends to expend half of it for the immediate erection of a proper building for storing astronomical photographs, and the other half as needs may arise. The reader is probably aware that Harvard Observatory, in conjunction with its station at Arequipa, takes photographs of the entire sky at frequent intervals. No attempt is made to examine the greater part of these; they are simply stored away for future reference. The great value of these photographs has been proven time and again. They have enabled astronomers to fix the time of the appearance of *Nova Aurigæ* in 1892 and of *Nova Persei* of last year. In a similar way our knowledge of *Eros,* discovered by WITT in 1898, was extended back several years. The first observations of many variables are also to be found on these plates. Professor PICKERING hopes to increase still further the usefulness of this ever-growing collection by making it accessible to all astronomers who care to consult it.

Professor PORTER, Director of the Cincinnati Observatory, states that the observatory is to have a 16-inch equatorial telescope, to be made by the firm of ALVAN CLARK & SONS. A 30-foot dome to accommodate such a telescope was erected at the observatory some years ago. The telescope is to be devoted to researches in the "old" astronomy of precision.

During the recent troubles in China some of the German soldiery removed the quaint astronomical instruments from Pekin's famous observatory and sent them to Berlin. There was considerable feeling in Germany that the instruments should be restored to China, but this is not to be done, as the following extract shows. It is from a speech by the Imperial German Chancellor, before the Reichstag, reported in the *New York Sun* of April 27:—

> "The instruments have not been restored because the Chinese Government attaches no importance to their possession, and in reply to German inquiries, it placed them at the disposition of the German Government. Another consideration is, that in accordance with the peculiar views of the Chinese, the great mass of that people would have supposed that the instruments were restored by order of the Chinese Government, which would have damaged German prestige in East Asia. The Dowager Empress of China, a very clever woman who understands the political situation, would have been distinctly offended, while the masses would have thought that Germany had sustained some terrible defeats. The instruments ought now to be placed in the category of presents from government to government, as this has long been customary on both sides in our intercourse with China."

S. W. BURNHAM, whose leisure has been so fruitful of astronomical discoveries, has resigned his office as clerk of the U. S. District Court for the Northern District of Illinois, and intends hereafter to devote all his attention to astronomy.

FRANK E. ROSS (Ph. D., University of California, 1901) has been appointed Computer in the Nautical Almanac Office at the Naval Observatory, Washington, D. C.

J. N. KRIEGER, an astronomer who occupied himself solely in the study of the Moon's surface, died at San Remo, Italy, in February last, in the thirty-seventh year of his age. KRIEGER'S observations were made at the Pia Observatory, at Triest, Austria. He had planned to publish a complete atlas of the Moon in eight volumes, only one of which, however, had appeared at the time of his death. The material for the other volumes is said to be nearly complete, and no doubt will be published eventually.

On February 24th, RICHARD SCHUMACHER, observer at the Royal Observatory at Kiel, Germany, died at the age of seventy-five years. He was the son of H. C. SCHUMACHER, founder of the *Astronomische Nachrichten,* and had been at various times connected with the observatories at Altona, Santiago (Chile), and Kiel.

ERRATUM.—In these *Publications,* No. 81, page 221, line 24, *for* 6th magnitude, *read* 8.6 magnitude.

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NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)

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PLANETARY PHENOMENA FOR SEPTEMBER AND OCTOBER, 1902.

BY MALCOLM MCNEILL.

SEPTEMBER.

The Sun crosses the celestial equator and the autumnal equinox occurs September 23d, 4 P.M., Pacific time.

Mercury is not favorably situated for naked-eye observation, although it is an evening star and at a considerable distance from the Sun. It reaches greatest east elongation on September 24th, and this elongation (26°) is the greatest east elongation for the year, since it occurs only eleven days after the planet passes its aphelion. But the planet is 10° south of the Sun, and this causes a great shortening of the interval between the setting of the Sun and the planet. The interval is less than one hour throughout the month. On September 20th *Mercury* passes 13′ south of the first magnitude star α *Virginis.*

Venus is still a morning star, but is beginning to approach the Sun quite rapidly, and the interval between rising of the planet and of the Sun shortens from about two hours to about an hour and fifteen minutes. It moves about 35° eastward and southward through the constellation *Leo,* and on September 11th passes south of the first-magnitude star *Regulus,* α *Leonis,* at a distance about equal to the Moon's apparent diameter.

Mars rises about three hours before the Sun; so it can be very easily seen in the early morning, although it has not yet brightened up enough to be at all conspicuous. It moves 19° east and 4° south in the constellation *Cancer.* No bright stars are near it, but it passes between γ and δ *Cancri* on September 15th.

Jupiter is above the horizon until after midnight. It is moving westward, retrograding, about 2° during the month in the constellation *Capricorn.*

Saturn is also in fine position for evening observation. It is in the same constellation as *Jupiter,* and about 17° west of that planet. Its motion is retrograde until September 26th, but is quite small in amount.

Uranus is in the western sky in the evening, and sets at about 9 P.M. at the close of the month. The nearest noticeable star is the third-magnitude *θ Ophiuchi,* 2° east and 2° south of the planet. The planet approaches the star about half a degree during the month.

Neptune rises before midnight soon after September 1st. It is in the western part of the constellation *Gemini.*

OCTOBER.

There will be an eclipse of the Moon on the evening of October 16th. It will be total, and will be visible generally throughout the United States. The totality will last from 9^h 19^m to 10^h 48^m, Pacific time, and the partial phase will begin about an hour before totality and continue an hour after totality is ended.

There will also be a partial eclipse of the Sun, visible only in the Eastern Hemisphere, on October 31st. The maximum obscuration will be about seven tenths of the Sun's diameter.

Mercury is too near the Sun to be seen until the end of the month, and passes inferior conjunction, becoming a morning star, on October 19th. It may be possible during the last few days to see it in the morning twilight, but the conditions are not very good.

Venus, which has been the brightest of the planets in the morning sky for months, is now drawing very close to the Sun and by the end of October rises only about half an hour before sunrise. However, the planet is so much brighter than the others that it may be possible to follow it throughout nearly the entire month.

Mars rises about one minute earlier each day, so that by the end of the month it appears above the horizon at a little after 1 o'clock in the morning. It can not, however, be seen by the naked eye for an hour or more after it rises, since it is still not very bright. It is about one quarter nearer us than it was in May, and consequently about twice as bright. It moves about 17° east and 6° south through *Leo,* and on October 20th it passes about 1° north of the first-magnitude star *Regulus,* α *Leonis.*

Jupiter sets two hours earlier than during September, but is still in fine position for evening observation. Shortly after the beginning of the month it resumes its eastward motion, and by the end of the month it has about the same position among the stars that it held in early September.

Saturn sets about an hour before *Jupiter,* but is still in good position for early evening observation. It also moves eastward about 1° during the month.

Uranus sets quite early in the evening, and is too low down after twilight disappears for easy identification.

Neptune rises late in the evening. It is moving slowly westward in *Gemini.*

SEPTEMBER–OCTOBER, 1902.

PHASES OF THE MOON, P. S. T.

New Moon, . . .	Sept. 1,	9^h	19^m	P. M.
First Quarter, . . .	Sept. 9,	2	15	
Full Moon, . . .	Sept. 17,	10	23	A. M.
Last Quarter, . . .	Sept. 24,	8	31	
New Moon, . . .	Oct. 1,	9	9	
First Quarter, . . .	Oct. 9,	9	21	
Full Moon, . . .	Oct. 16,	10	1	P. M.
Last Quarter, . . .	Oct. 23,	2	58	
New Moon, . . .	Oct. 31,	12	14	A. M.

THE SUN.

1902.	R. A.	Declination.	Rises.	Transits.	Sets.
Sept. 1,	$10^h\ 39^m$	+ 8° 32′	$5^h\ 31^m$ A. M.	Noon	$6^h 29^m$ P. M.
11,	11 15	+ 4 49	5 41	$11^h\ 57^m$ A. M.	6 13
21,	11 51	+ 0 58	5 50	11 53	5 56
Oct. 1,	12 27	— 2 55	6 0	11 50	5 40
11,	13 4	— 6 46	6 10	11 47	5 24
21,	13 41	— 10 28	6 21	11 45	5 9
31,	14 19	— 13 54	6 32	11 44	4 56

Mercury.

Sept.	1,	11 46	+ 1 54	7 0 A.M.	1 7 P.M.	7 14 P.M.
	11,	12 38	− 5 12	7 37	1 20	7 3
	21,	13 23	−11 15	8 4	1 25	6 46
Oct.	1,	13 56	−15 24	8 12	1 18	6 24
	11,	14 1	−15 44	7 39	12 44	5 49
	21,	13 26	− 9 45	6 3	11 30 A.M.	4 57
	31,	13 14	− 5 51	4 59	10 39	4 19

Venus.

Sept.	1,	9 13	+16 53	3 35 A.M.	10 34 A.M.	5 33 P.M.
	11,	10 1	+13 15	3 57	10 43	5 29
	21,	10 49	+ 8 59	4 20	10 51	5 22
Oct.	1,	11 35	+ 4 18	4 44	10 58	5 12
	11,	12 21	− 0 38	5 5	11 4	5 3
	21,	13 7	− 5 35	5 30	11 11	4 52
	31,	13 53	−10 22	5 54	11 18	4 42

Mars.

Sept.	1,	8 1	+21 29	2 5 A.M.	9 22 A.M.	4 39 P.M.
	11,	8 28	+20 12	1 58	9 10	4 22
	21,	8 53	+18 42	1 50	8 56	4 2
Oct.	1,	9 18	+17 2	1 42	8 41	3 40
	11,	9 42	+15 15	1 33	8 26	3 19
	21,	10 5	+13 21	1 23	8 9	2 55
	31,	10 27	+11 24	1 13	7 52	2 31

Jupiter.

Sept.	1,	20 47	−18 52	5 13 P.M.	10 6 P.M.	2 59 A.M.
Oct.	1,	20 40	−19 18	3 10	8 2	12 54
Nov.	1,	20 45	−18 56	1 12	6 5	10 58 P.M.

Saturn.

Sept.	1,	19 34	−21 51	4 12 P.M.	8 53 P.M.	1 34 A.M.
Oct.	1,	19 32	−21 57	2 13	6 54	11 35 P.M.
Nov.	1,	19 36	−21 49	12 14	4 56	9 38

Uranus.

Sept.	1,	17 5	−22 56	1 48 P.M.	6 25 P.M.	11 2 P.M.
Oct.	1,	17 7	−22 59	11 52 A.M.	4 29	9 6
Nov.	1,	17 12	−23 5	9 55	2 32	7 9

Neptune.

Sept.	1,	6	15	+ 22	18	12	15 A.M.	7	36 A.M.	2 57 P.M.
Oct.	1,	6	16	+ 22	17	10	19 P.M.	5	40	1 1
Nov.	1,	6	15	+ 22	16	8	16	3	37	10 58 A.M.

Eclipses of *Jupiter's* Satellites, P. S. T.

(Off right-hand limb as seen in an inverting telescope.)

I, R,	Sept. 1,	2h 40m A.M.	III, D,	Oct. 1,	5h 25m P.M.
I, R,	2,	9 9 P.M.	III, R,	1,	8 58
II, R,	5,	10 35	I, R,	2,	11 18
I, R,	9,	11 4	I, R,	4,	5 47
I, R,	11,	5 32	II, R,	7,	10 22
II, R,	13,	1 12 A.M.	III, D,	8,	9 26
IV, R,	15,	4 53 P.M.	III, R,	9,	12 59 A.M.
I, R,	17,	12 59 A.M.	I, R,	11,	7 42 P.M.
I, R,	18,	7 26 P.M.	I, R,	18,	9 38
II, R,	23,	5 7	I, R,	20,	4 7
III, R,	24,	4 57	II, R,	25,	4 56
I, R,	25,	9 23	I, R,	25,	11 33
I, R,	27,	3 52	I, R,	27,	6 2
II, D,	30,	7 44			

DEFINITIVE DETERMINATION OF THE ORBIT OF COMET 1898 I.

[Abstract of No. 3 of the *Astronomische Abhandlungen.*]

By Heber D. Curtis.

Comet 1898 I was discovered by Professor C. D. Perrine at Mt. Hamilton on March 19, 1898. At this date it was about equal to a sixth-magnitude star, with a head nearly 2′ in diameter and a broad fan-shaped tail about a degree in length. In all, the comet was observed 666 times at thirty-four observatories. Deducting for incomplete observations, 640 were made in Right Ascension and 639 in Declination. The comet had just passed perihelion (March 17th) and was visible for nine months, during which time it swept over a heliocentric arc of 110°.

The comet presented no unusual phenomena in physical appearance or spectrum, with the exception of a sharp fan-shaped jet in the head, which was observed by PERRINE on April 7th, and was still visible one month later. There was a very well-marked nucleus, which in good seeing was of starlike sharpness. Traces of this nucleus were still seen at Mt. Hamilton in the middle of September.

Telescopic comets of long apparition period and considerable range in distance from the Sun and from the Earth afford an excellent test for the applicability of the various laws which have been suggested in explanation of the decrease in the light of comets as they recede from the Sun. Estimates on such objects can be made in magnitudes much as stars are compared, and with much the same accuracy. As Comet 1898 I had a range of over ten magnitudes (6.5 to 16.7) during the nine months of its apparition period, in which time its radius-vector varied in length from 1.1 to 3.5 units, it may be of interest to compare its loss of light with the various formulæ which have been suggested. Eighty-eight estimates of the brightness of the comet as a whole were made at various observatories and sixty-seven of the starlike nucleus. The loss of light in the nebulosity as a whole and in the nucleus seems to have been synchronous, and to have obeyed the same law within the limits of observation, but neither comet nor nucleus follows the formulæ $J = \frac{C}{r^2}$ (DEICHMULLER, *A. N.*, 3123), $J = \frac{C}{\Delta^2}$ (OLBERS, *B. J.* 1819), nor the commonly accepted one, $J = \frac{C}{r^2 \Delta^2}$, the difference on November 15th for the last expression being nearly seven magnitudes. The attempt was made to ascertain whether the variation in brightness could be expressed in the form $J = \frac{C}{\phi(r) \Delta^2}$. The various formulæ were applied to this comet and to several other comets of long apparition period, but no simple function of the inverse of r and Δ was found which would harmonize all the data. In the last column of the following abridged table will be found the residuals, in magnitudes, in the sense observation minus computation, secured on the assumption that the light varied in accordance with the formula $J = \frac{C}{r^7 \Delta^2}$. This formula is of course purely empirical and rests upon no physical basis; it is of interest simply in showing the inadequacy of the ordinary formula $J = \frac{C}{r^2 \Delta^2}$ for this comet.

a. Comet.

Place of Observation.	Date 1898.	Observed Mag.	O–C $C/r^2 \Delta^2$	O–C $C/r^7 \Delta^2$
Mt. Hamilton..	March 20 0	6.0	—0.5	—0.5
Utrecht........	April 1.6	7.	+0 4	+0.4
Vienna........	May 1.5	7.4	+0.2	—0.5
Munich........	May 2.4	8.5	+1.3	+0 5
Munich........	June 4.4	10.3	+2.1	0.0
Mt. Hamilton..	June 19.9	10.	+1.4	—1 2
Munich......	July 16.5	12.0	+2.9	—0.6
Mt. Hamilton..	July 23.0	12.8	+3.6	—0.2
" "	Aug. 12.9	13.5	+4.0	—0.3
" "	Sept. 10.0	16.	+6.2	+1.3
" "	Nov. 6.8	16.8	+6.8	+0.4
" "	Nov. 15.8	16.8	+6.7	+0.5

b. Nucleus.

Place of Observation.	Date 1898.	Observed Mag.	O–C $C/r^2 \Delta^2$	O–C $C/r^7 \Delta^2$
Bamberg......	March 22.6	8.9	+0.9	+0.9
Mt. Hamilton..	March 30.0	8.0	0.0	—0.2
Utrecht........	April 13.5	9.0	+0.7	+0.4
Utrecht........	May 11.5	9.5	+0.4	+0.2
Mt. Hamilton..	June 6.0	11.5	+1.7	—0.6
" "	June 28.9	13.3	+2.9	0.0
" "	July 10.0	14.	+3.5	+0.3
" "	July 30.0	16.	+5.2	+1.3
" "	Aug. 14.9	16.5	+5.4	+1.1
" "	Sept. 18.0	17.?	+5.7	+0.6
" "	Oct. 14.9	16.5	+5.1	+0.3

The observations depend upon 354 comparison-stars, whose places were determined after a comparison of all available catalogue places. The parallax factors were recomputed with a value of 8″.80 for the Sun's parallax and the reductions to apparent place carefully checked.

The probable errors and weights to be assigned to each observer were found in part graphically, and from the weighted residuals nine normal places were formed. The comet did not pass near any of the planets, but the perturbations in rectangular coördinates were computed at intervals of sixteen days during the apparition period for all the planets except *Uranus* and *Neptune*.

The dates of the normal places, the residuals and the perturbations are given in the annexed table:—

EPOCH OF OSCULATION: MARCH 31.0.

No.	1898	$\Delta\alpha \cos\delta$	Pert. α	Weight	$\Delta\delta$	Pert. δ	Weight	OBSERVATIONS.	
								From	To
		″	″		″	″			
I	March 25.5	−1.65	+0.002	132.5	−1.20	−0.001	153.0	March 19	March 31
II	April 14.0	−0.72	+0.005	291.0	−2.18	−0.011	331.5	April 1	April 30
III	May 15.0	+1.22	+0.053	170.0	−1.57	−0.141	220.0	May 1	May 31
IV	June 16.0	+2.34	+0.387	51.0	−1.90	−0.259	83.0	June 1	June 30
V	July 18.5	+0.98	−0.954	27.0	−0.79	−0.243	54.0	July 1	July 31
VI	Aug. 20.5	−4.18	−1.786	8.0	+1.58	−0.147	16.0	Aug. 12	Aug. 28
VII	Sept. 16.5	−7.26	−2.725	10.0	−0.14	−0.100	20.0	Sept. 10	Sept. 19
VIII	Oct. 15.5	−9.78	−4.042	4.0	+2.35	−0.332	8.0	Oct. 8	Oct. 19
IX	Nov. 11.5	−6.30	−5.330	7.0	+0.81	−0.452	14.0	Nov. 6	Nov. 15

From these by the usual methods and with the application of the usual checks the following corrections to the elements were derived:—

$$
\begin{aligned}
dT &= +\,0^{d}.011825 \pm 0^{d}.001679 \\
d \log q &= +\,0\,.0000524 \pm 0\,.0000093 \\
d\pi' &= +\,1'\ \ 8''.52 \pm 11''.03 \\
d\Omega' &= +\,0\ \ 18\,.07 \pm 3\,.21 \\
d i' &= -\,0\ \ \ 1\,.80 \pm 0\,.49 \\
d e &= +\,0\,.0004639 \pm 0\,.0000706
\end{aligned}
$$

$$[vv] = 30''.64 \qquad [p\,vv] = 449''.1 \qquad [n\,n\,6] = 450''.5$$

The sum of the squares of the weighted residuals has thus been reduced from 4213″ to 450″.

From these are derived the following definitive elements:—

EQUINOX OF 1898.0.

$$
\begin{aligned}
T &= 1898 \text{ March } 17.13078 \text{ Gr. M. T.} \\
\omega &= 47^{\circ}\ 19'\ 11''.85 \\
\Omega &= 262\ \ 26\ \ 19\,.06 \\
i &= 72\ \ 31\ \ 47\,.01 \\
\log q &= 0.0395112 \\
e &= 0.9803852 \\
\text{Period} &= 417.2 \pm 2.2 \text{ years}
\end{aligned}
$$

In inclination and longitude of the node it somewhat resembles Comet Pons-Brooks, 1884, but here the resemblance ceases. Comets 1861 I and 1861 II, both well determined, have approximately the same period, but no other likeness except a high inclination, that of 1861 I being 85° 26′, and 1861 II, 79° 46′.

NOTICES FROM THE LICK OBSERVATORY.[*]

PREPARED BY MEMBERS OF THE STAFF.

A LIST OF SIX STARS WHOSE VELOCITIES IN THE LINE OF SIGHT ARE VARIABLE.[†]

The following six spectroscopic binaries, discovered with the Mills spectrograph, are additional to the thirty-two binaries already announced:—

ϕ *Persei* ($\alpha = 1^h\ 37^m$; $\delta = +50°\ 11'$).

The variable velocity of this star was discovered from the second plate. The observations are:—

Date.	Velocity.	Measured by
1898, September 5	-2^{km}	REESE.
1900, December 16	$+24$	REESE.
"	$+23$	CAMPBELL.
1901, October 15	-10	REESE.
November 11	-12	REESE.

This star has bright hydrogen lines, its bright $H\beta$ having been discovered by ESPIN (*Astr. Nach.*, No. 2963). The $H\gamma$ line may perhaps be best described as a comparatively narrow absorption line with very bright borders. The measures refer to the middle of the dark line. No other lines are apparent in the $H\gamma$ region.

η *Geminorum* ($\alpha = 6^h\ 09^m$; $\delta = +22°\ 32'$).

The observations of this star thus far secured are as follows, the variable velocity having been discovered from the third plate:—

Date.	Velocity.	Measured by
1900, January 15	$+15.8^{km}$	REESE.
"	$+14$	STEBBINS.
January 21	$+15.0$	REESE.

---

[*] Lick Astronomical Department of the University of California.

[†] From Lick Observatory Bulletin No. 20.

Date.		Velocity.	Measured by
1901, October	13	+22.1	Reese.
November	6	+20.3	Reese.
December	4	+22.8	Reese.
1902, February	2	+25	Reese.
"		+23	Stebbins.

γ *Canis Minoris* ($\alpha = 7^{h}\ 23^{m}$; $\delta = +9^{\circ}\ 08'$).

The observations of this star are:—

Date.		Velocity.	Measured by
1900, October	29	$+44^{km}$	Reese.
"		+44	Stebbins.
1901, November	6	+41	Reese.
"		+40	Stebbins.
December	22	+54	Reese.
"		+53	Stebbins.
December	30	+50	Reese.

The fourth plate is underexposed.

ζ *Herculis* ($\alpha = 16^{h}\ 38^{m}$; $\delta = +31^{\circ}\ 47'$).

Early observations of the radial velocity of this star were obtained by Belopolsky at Pulkowa, Campbell at Mount Hamilton, and Newall at Cambridge, as follows:—

Date.		Velocity.	Measured by
1893, May	18	-68^{km}	Belopolsky.
May	22	−84	Belopolsky.
June	2	−75	Belopolsky.
June	3	−67	Belopolsky.
June	4	−66	Belopolsky.
June	14	−64	Belopolsky.
June	16	−69	Belopolsky.
Mean		−70.4	
1897, April	29	−69.1	Campbell.
1898, May	11	−70.4	Campbell.
May	23	−70.0	Campbell.
August	19	−70.9	Campbell.
Mean		−70.1	
1897, June	14	−71.4	Newall.
1898, May	16	−68.4	Newall.
1899, April	29	−74.3	Newall.
Mean		−71.4	

The above observations afforded no evidence whatever of variable velocity.

Recent observations at the Lick Observatory are as follows:—

Date.		Velocity.	Measured by
1901, July	1	-74^{km}	Wright.
"		-73.9	Reese.
August	6	-75.8	Reese.
1902, April	13	-74.2	Reese.
Mean		-74.6	

The velocity has therefore changed about 4^{km} since 1898.

This star is a well-known visual binary, period about 33 years.

α *Equulei* ($\alpha = 21^h\ 11^m$; $\delta = +4^\circ\ 50'$).

The variable velocity of this star was detected from the third of the following observations:—

Date.		Velocity.	Measured by
1900, June	25	-26^{km}	Wright.
July	18	-22	Wright.
1901, June	25	-2	Wright.
September	1	-14	Wright.
October	15	-12	Reese.
1902, June	2	-26	Stebbins.

This star has a composite spectrum, discovered by Miss Maury, of Harvard College Observatory.

o *Andromedæ* ($\alpha = 22^h\ 57^m$; $\delta = +41^\circ\ 47'$).

The following observations of this star have been secured:—

Date.		Velocity.	Measured by
1900, October	9	-11^{km}	Wright.
December	17	-15	Campbell.
"	17	-17	Wright.
1901, June	25	-20	Wright.
August	12	-12	Reese.

These measures depend entirely upon the excellent $H\gamma$ line.

This star has a composite spectrum, discovered likewise by Miss Maury.

Before the discovery of the thirty-eight spectroscopic binaries with the Mills spectrograph, three had been discovered in the same list of stars by Belopolsky, making forty-one binaries in about 350 stars observed. The proportion is therefore one binary star for every eight observed, not taking into account a considerable list of suspected cases awaiting confirmation. The variable velocity of our Sun, due to its revolving planets, has a double amplitude of only a few hundredths of a kilometer. As the work progresses, and the degree of accuracy attainable increases, we shall probably find that there is a regular gradation of double amplitudes from that of the Sun up to those of the spectroscopic binaries already discovered, and it is possible that the star which is not a spectroscopic binary will prove to be the rare exception.

Acknowledgements are due to Messrs. WRIGHT and REESE for continued efficient assistance in the line of sight work.

July 1, 1902. W. W. CAMPBELL.

GIFT TO THE LICK ORSERVATORY.

Mr. D. O. MILLS has again shown his interest in astronomical work by providing the sum of one thousand dollars to defray the expenses of reconstructing the Mills spectrograph. Dr. REESE has designed the new mounting. It will be constructed as far as possible of steel, and will include improvements suggested by our six years' experience with the Mills spectrograph.

W. W. CAMPBELL.

January, 1902.

GIFT TO THE LICK OBSERVATORY.

The thoughtful generosity of Mrs. PHŒBE A. HEARST, Regent of the University of California, has increased the available resources of the Lick Observatory for the calendar year 1902 to the extent of twenty-five hundred dollars. This sum is to be devoted to equipment purposes, and the efficiency of several of our departments will be greatly increased thereby.

June 12, 1902. W. W. CAMPBELL.

ANNOUNCEMENT CONCERNING ASTRONOMICAL PHOTOGRAPHS.

There has been a great demand in the past two years from institutions, investigators and teachers for copies of the Lick Observatory photographs of astronomical subjects. The unusual pressure of observational duties and the smallness of the staff has prevented compliance with these legitimate demands.

This is to announce that the Observatory is now prepared to supply lantern slides, transparencies, prints, etc., of any negatives in its collection, at moderate expense. It is assumed that such copies would be used for purposes of study and investigation; but the right to publish any or all copies without special permission from the Director of the Lick Observatory would not attach to the sale.

The collection of photographs in our possession is so extensive that it is not practicable to supply a detailed list. It includes the following subjects: The Sun; The Moon; Total Solar Eclipses (of January, 1889; December, 1889; April, 1893; January, 1898; May, 1900; May, 1901); Milky Way; Comets; Meteors; Spectra of nebulæ, comets, new stars, bright-line stars, coronas, stars for radial velocities, etc.; Crossley reflector photographs of nebulæ, star clusters, asteroids, etc., and of the nebulosity surrounding *Nova Persei;* Buildings, instruments, and views at the Lick Observatory; Miscellaneous.

Orders and inquiries may be addressed to the Director.

July 1, 1902. W. W. CAMPBELL.

NOTE ON THE SPECTRUM OF *NOVA PERSEI.*

Spectrograms of *Nova Persei* were secured at intervals during the fall and winter, up to January 7th. The spectrum remained, without appreciable change, as described by us in *Bulletin* No. 8. In that publication attention was called to the presence of the fine dark *H* calcium absorption-line; and the opinion was ventured that perhaps the corresponding *K* line was "absent only by reason of the fact that there the calcium vapor has nothing to absorb." To test this point, Mr. WRIGHT made a long exposure, sufficient to record the continuous spectrum in the *H* and *K* region. The fine dark *K* line is present.

In this connection it would be exceedingly interesting to know whether the absorption-lines of calcium, sodium, and other elements would be detected in the spectra of well-known gaseous nebulæ,—the exposures being long enough to record the continuous portions of their spectra.

W. W. CAMPBELL.
July 1, 1902. W. H. WRIGHT.

D. O. MILLS EXPEDITION TO THE SOUTHERN HEMISPHERE.

The 37¼-inch Cassegrain reflecting-telescope mirror, to be used by the Mills Expedition in determining the radial velocities of the brighter stars south of —30° Declination, was completed by the John A. Brashear Company on June 20th. The 9¾-inch convex secondary mirror has likewise been completed. Both are en route to Mt. Hamilton. The telescope mounting, designed in general plan by the Director, and in detail by the builders, HARRON, RICKARD & McCONE, of San Francisco, has for several months been set up for trial in the rear of the Observatory buildings. A three-prism spectrograph, designed by the Director, optical parts by BRASHEAR, and mounting by our instrument-maker, has been completed and tested. A modern steel dome, 30 feet in diameter, has been constructed by the Warner & Swasey Company. It is hoped that the expedition may be able to sail early in August for Valparaiso, to occupy a station near Santiago, Chile.

July 1, 1902. W. W. CAMPBELL.

NOTE ON VARIABLE STARS.

Harvard College Observatory Circular No. 65, under date of May 6th, contains the announcement of an interesting new variable star of the *Algol* type:—

> "A striking illustration of the value of the library of glass photographs collected at this observatory during the past seventeen years has been shown within the last few days. Comet *a* 1902 was discovered by Dr. BROOKS on April 14th, and it was found that a photograph had been taken here on April 3d with the 8-inch Draper telescope, approximately in the direction from which the comet came. An examination of this plate was accordingly made by Mrs. FLEMING, superposing it upon another plate of the same region taken with the same instrument on March 7, 1900. No trace of the comet was found, and in fact the elements now indicate that it was a little beyond the region covered by the photograph. One star, however, in the constellation *Lacerta*, according to HEIS, but in *Cygnus* according to the *Uranometria Nova*, appeared faint on the early plate and bright on that taken later. A further examination showed that this object was the north-preceding component of +43°.4101. Its position for 1900 is R. A. = $21^h\ 55.2^m$, Dec. = +43°52′. The difference in Right Ascension of the two components is about $2^s.0$; the difference in Declination, 0′.3. A further examination showed that the star was generally bright and constant in light, so that it must be a variable of the *Algol* type."

An examination showed that this star had been photographed 407 times. On 388 of the plates the star was of maximum brightness (8.9), but on the other 19 plates the magnitude was less than 8.9. From a discussion of this material. Professor PICKERING concludes that the period of the variable is 31.4 days, more than three times as long as that of any other known star of the *Algol* type. The star remains at maximum brightness for 28 days, and takes about three days to go through its minimum, decreasing from 8.9 to 11.6 magnitude.

This star was observed here photometrically with the 12-inch equatorial on the nights of June 29th, 30th, and July 1st. The actual minimum was not obtained, as it came in the daytime, but a curve through the observations shows that the minimum occurred at a time very close to that predicted by Professor PICKERING. The next minimum, July 31^d 19^h 26^m G. M. T., will be more favorable, and it is hoped to obtain observations of it.

I have also under observation a list of about twenty other new variable stars, and four variables of very faint minima are being followed with the 36-inch refractor.

S. D. TOWNLEY.

MEASUREMENT OF CLOSE DOUBLE STARS.

Dr. HERMANN STRUVE, Director of the Königsberg Observatory, has recently advanced a doctrine in reference to the measurement of close double stars which will hardly be acceptable to double-star observers, who have the use of telescopes of the largest sizes and good atmospheric conditions. He states it as his opinion that, even under the most favorable circumstances, when the distance between the components of a double star is less than $0''.40$ approximate estimations only of the position-angle can be obtained, and when the distance is under $0''.50$ that it has not been demonstrated that the distance is given more accurately by micrometer measurement than by mere estimation, and, further, he regards the results of the attempts which have been made to supply this demonstration as purely illusory.

Every one of experience will, I think, be ready to admit that when an observer has become accustomed to a given telescope and given eye-pieces in connection with it, he may acquire an accuracy in the estimation of small angular distances which is surprisingly near the truth. But before he can make such estimates he must acquire a knowledge of the scale of his instrument and the effect of the eye-pieces employed. Now this knowledge can only be obtained practically by measuring distances of the same order of magnitude as those to be estimated or by relying upon such measures already made by an observer of experience. In either case the estimates, to be reliable, must be based upon measured or measurable quantities.

The angular diameter of the central disk of the image of a star of the fifth or sixth magnitude as formed by the thirty-six-inch refractor of the Lick Observatory is not much more than 0".10; the theoretical value is 0".13. The disks for faint stars are somewhat smaller than for bright ones. The apparent thickness of the spider threads used as micrometer-wires in this instrument is very approximately 0".10. When the atmospheric conditions are favorable, giving good images of the stars, and when a sufficiently high power is used the micrometer-wire even when fully illuminated may be seen as a dark line crossing and almost concealing the central disk of the star which it bisects. The appearance of the wire as a dark line crossing the disk makes the bisection of the disk perfectly definite; it also makes perfectly definite the simultaneous bisection of two separated disks as in the measurement of position-angle by means of a single wire, or of the distance by the use of two.

A double star having components equal or nearly equal in brightness can be measured with this instrument under such atmospheric conditions as often prevail at Mt. Hamilton, whenever the distance between the components is greater than the thickness of a micrometer-wire. When the distance is somewhat less than this, an elongation of the image is still very apparent and an approximate determination of the position-angle and distance may be obtained by measurement and not by mere estimation. When the apparent distance becomes as small as 0".05, the images coalesce and appear almost or quite round, even with the highest powers that are used; viz., 2400 and 2600. For distances greater than 0".15 the images of the stars under good atmospheric conditions are clearly separated, and then measures can be made with certainty. For a distance of a third of a second the images are separated by a space of several times their own diameters, and there is then no excuse here for estimating such a distance rather than measuring it.

W. J. Hussey.

Discovery of the Double Star *Iota Serpentis*.

With the thirty-six-inch refractor on the night of July 17, 1902, I found this 4.5th-magnitude star to be a close double. The components are of sensibly the same brightness. My measures of position angle and distance are as follows:—

1902.542	71°.4	0″ 20	
.545	72 .3	0 .21	
1902.54	71°.8	0″.20	2 n.

The position of *ι Serpentis* for the epoch 1900.0 is:—

$$\text{R. A.} = 15^{h}\ 37^{m}\ 5^{s}.51.$$
$$\text{Decl.} = +\ 19^{\circ}\ 59'\ 32''.2.$$

Its proper motion is small.

I have also found some other new double stars in this vicinity. The 7.5th-magnitude star 4′ north and 9^{m} preceding *ι Serpentis* is one of these. Its distance is about a third of a second, and the components are of the same magnitude.

W. J. Hussey.

Changes in the Lick Observatory Staff.

Dr. Heber D. Curtis has been appointed Assistant in the Lick Observatory for three years, dating from the departure of the Mills Expedition to Chile, with principal duties in spectroscopy. Dr. Curtis is a graduate of Michigan University, A. B., '92, and A. M., '93; was professor of mathematics and astronomy in the University of the Pacific, 1897-1900; was an eclipse observer in Georgia, 1900, and Sumatra, 1901; and has this year taken his Ph. D. degree at the University of Virginia.

Mr. C. A. G. Weymouth, of the class of 1902, University of California, has been appointed Fellow in Astronomy at the Lick Observatory.

W. W. Campbell.

Honorary Degree for Director Campbell.

The University of Wisconsin conferred the honorary degree of Doctor of Laws upon Professor W. W. Campbell, Director of the Lick Observatory, at the last annual commencement, June 19, 1902.

In sending the diploma, the Acting-President, Dr. E. A. Birge, writes: "I am very glad that it is possible for the University of Wisconsin to recognize in this way your distinguished work, both as scientist and as the administrative officer and head of the great observatory which is under your charge."

Publication Committee.

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in the work of this department. Communications to this end may be sent to Frank Schlesinger, International Latitude Observatory, Ukiah, California.

The Force of Gravity at the Surface of the Earth.—Among the most useful instruments which the astronomer has at his disposal must be counted the pendulum. Not only does it furnish him with an accurate timepiece in his observatory, but it has enabled him to learn much about the shape of the Earth and the distribution of the material forming the Earth's crust. So important are these applications of the pendulum that many expeditions for this purpose have been sent to remote regions, chiefly during the last twenty years. At the present time the intensity of gravity has been determined at about fifteen hundred places, widely scattered over the Earth's surface. Dr. HELMERT, head of the Central Bureau of the International Geodetic Association at Potsdam, has recently issued a complete report on pendulum observations. This report contains an interesting map showing the distribution of the fifteen hundred stations. By far the greater number of these are in Europe; the badly neglected continents are South America and Australia, the former containing only eleven stations, and the latter only five. Thanks to many pole-seeking expeditions, the Arctic regions have been well surveyed as regards pendulum experiments. The most northerly station is in latitude 85° 55', occupied by NANSEN in 1895. On the other hand, the Antarctic regions are totally vacant, the most southerly stations being in latitudes 63° and 56°, respectively. In Europe, in the United States, and in India there are many inland stations, but elsewhere the observations have almost exclusively been confined to the seacoast.

Within the past few months a method has been developed for the determination of gravity which, although much less accurate than pendulum experiments, has a larger sphere of usefulness, in that it may be employed at sea. Pendulum observations are, of course, impossible on the ocean, owing to the inevitable rolling of vessels. In the new method observations are made with a barometer and an hypsometer, the latter being an instrument for the precise determination of the temperature at which water boils. As this varies with the pressure to which the water is subjected (being greater for high pressures), we may thus compute with considerable exactness the atmospheric pressure. Now, the barometer may be employed for the same purpose, but it will give precise results only if corrected for the intensity of gravity acting upon the mercury. It will therefore be seen that simultaneous observations with these two instruments, placed at the same height above sea-level, will enable us to compute the intensity of gravity at any place.

A series of such experiments was made last year by Dr. HECKER on the Atlantic Ocean. Six hypsometers and four mercurial barometers were employed, accordant results being obtained from all these instruments. The result of Dr. HECKER's observations is to show that the intensity of gravity on the sea is *normal;* that is, it is equal to the intensity upon the land in the same latitude. At first sight this result might seem an improbable one, because of the small density of the sea (about forty per cent) compared with that of the land at the Earth's surface. As the ocean is usually two or three miles deep, it will be seen that there is much less *mass* immediately under a vessel than under a point on land, and consequently we should expect gravity at sea to be less than normal. But it has been known for many years (or at least been regarded as probable) that the crust of the Earth underlying the ocean is more dense than elsewhere. Thus pendulum experiments on small isolated islands indicate greater gravity than normal; this is really equivalent to the case on the open sea, with the addition of the excess of the mass of the island over that of the water it displaces. Again, accurate geodetic operations show that the plumb-line on the shores of the ocean is deflected toward the latter. Finally, Arctic explorers have occasionally been able to make pendulum observations on the solid ice covering the deep sea, and these observations show normal intensities. It is interesting to note that the greater density of the Earth's crust underlying the oceans was deduced almost wholly from theoretical considerations by Archdeacon PRATT, of Calcutta, about the middle of the last century. The importance of Dr. HECKER's observations lies in the confirmation they afford of

PRATT's hypothesis, or, as it is sometimes called, the *isostatic* hypothesis.

Variations of Latitude.—Three important papers on this subject have recently appeared,—two by Dr. CHANDLER, and the third by Professor KIMURA, who has charge of the Japanese station of the International Latitude Service. Dr. CHANDLER's first paper is a "New Study of the Polar Motion for the Interval 1890–1901" (*Astronomical Journal,* No. 522), the former date corresponding to the first accurate observational data on the subject. The discussion is notably unbiased by the author's previous researches, and the results differ somewhat from those formerly published by him. According to the present paper the path of the pole is the resultant of three independent terms: (1) a circular motion, having a period of *fourteen* months; (2) an *annual* motion in a flat ellipse; and (3) a motion in an ellipse of slight eccentricity, and having a period of about *thirteen* months. The second of Dr. CHANDLER's papers to which we have referred above is "On the Possible Existence of Still Another Term of the Polar Motion." This was put into a separate paper, in order, as the author says, "to separate what was fairly demonstrated, as it seemed to me, from what was problematical." The new term has a period of *fifteen* months and is extremely minute, having a coefficient of 0".025. It will be seen that the polar motion, as defined in these two papers, is by no means a simple one, especially since some of the elements of the separate motions appear to be subject to slow changes; notably the amplitude of the first term, that with a period of fourteen months.

The third paper adds to the complexity of this already complex subject. Professor KIMURA shows that there is a variation, having a semi-amplitude of only 0".03, and an annual period, which affects all stations alike, no matter how much they may differ in longitude,—that is, the effect is the same as though the center of gravity of the Earth were movable along the axis of rotation. If the mass of the Earth were all concentrated at its center, a movement of only five feet would account for Professor KIMURA's variation. Whether this term is real is a question which needs further data to decide. The evidence deduced by KIMURA in favor of its existence is strong, but the effect is very small, and the data were of necessity derived from observations made only in the Northern Hemisphere. Furthermore, as the term has an *annual* period, the effect may be an instrumental one. It is a fact, perhaps not without significance, that the maxima of KIMURA's variation occur in July and January, when the Northern Hemisphere is hottest and coldest, respectively.

These three papers not only indicate the still unsettled nature of our knowledge of the subject, but they attest to the accuracy of modern latitude observations, permitting of the discovery and discussion of terms having coefficients of only two or three hundredths of a second.

In the death of MARIE-ALFRED CORNU, which occurred near Orleans, France, in April last, almost every branch of physical science has suffered a direct loss. Although in his sixty-second year, CORNU was unusually active, physically and mentally, and his death was most unexpected. To astronomers he was best known through his determinations of the mean density of the Earth and of the velocity of light. Both these determinations exceeded in accuracy any work that had preceded them, and are still among the standard ones. Besides these, he has made many valuable contributions to astrophysics and some to astronomy of precision. One of the latest of these was his design for a "zenith-nadir" instrument, to be used in determining the constant of aberration and the variation of latitude.

TH. BREDIKHINE, the well-known astronomer at Moscow, Russia, has established a biennial prize of about two hundred dollars as a memorial to his late wife. The prize is to be "for the encouragement to the continuation of the work of TH. BREDIKHINE on the development of cometary forms, from a purely mechanical point of view."

The Secretary of the Smithsonian Institution has granted an annual award of two hundred dollars for a period of four years to the *Astrophysical Journal.* This is to be used in maintaining the high standard of excellence of the *Journal,* especially as regards illustrations.

The Catalogue of the Astronomische Gesellschaft.—Two new installments of this great work have been distributed, those for the zones 30°–35° and 35°–40°. Only one more zone, 70°–75°, remains to be published. The following table gives some of the details concerning the various parts of the catalogue:—

Zone.	Observatory.	Date when Published.	No. of Stars.
75° - 80°	Kasan	1898	4,281
70 - 75	Dorpat	. .	. .
65 - 70	Christiania	1890	3,949
55 - 65	Helsingfors and Gotha	1890	14,680
50 - 55	Harvard	1892	8,627
40 - 50	Bonn	1894	18,457
35 - 40	Lund	1902	11,446
30 - 35	Leiden	1902	10,239
24¼ - 31	Cambridge, Eng.	1897	14,464
20 - 25	Berlin	1895	9,208
15 - 20	Berlin	1896	10,161
10 - 15	Leipzig	1900	9,547
5 - 10	Leipzig	1899	12,785
1 - 5	Albany	1890	8,241
-2 - +1	Nicolajew	1900	5,954

The whole catalogue, extending from South Declination 2° to North Declination 80°, covers a little more than half the area of the sky, and when the Dorpat zone is published will contain observations of the highest order on more than 130,000 separate stars. A southern continuation of the catalogue is in progress, to be called "Part Two of the Catalogue of the Astronomische Gesellschaft." As regards the area between 80° North Declination and the pole, it will be remembered that this is so well covered by CARRINGTON'S "Catalogue of 3,735 Circumpolar Stars" (1857) that it was deemed unnecessary to include this part of the sky in the Gesellschaft programme.

Astronomischer Jahresbericht for 1901.—The third volume of this important publication does not differ in any material respect from its two predecessors. It contains reviews of 2,513 papers and books on astronomical and closely related subjects, as against 1,768 and 2,320 for the first and second volumes, respectively. The increase over the second volume is due to the appearance of *Nova Persei* in February, 1901, as no less than 228 reviews are devoted to this subject alone in the volume before us.

The work of reviewing so much material has, as heretofore, been done with truly astonishing completeness. How Dr. WISLICENUS can find time, in addition to his other duties, to read and epitomize an average of five papers or books a day is not easy to understand; and those who have had occasion to use the work will bear out the assertion that it shows no signs of having been hastily done. Almost all the reviews are written by Dr. WISLICENUS himself, the assistant editors serving chiefly to review works in the more uncommon languages. In this way it has been possible to include in the current volume reviews of papers in at least fourteen languages. It has been urged more than once against the *Jahresbericht* that too much space is devoted to reviewing popular articles. In this criticism we cannot concur; the work is thereby made more useful to amateurs, and it must be confessed that professional astronomers will profit by it as well,—for it is notorious that the latter, as a rule, do not spend much time upon technical papers outside of their own specialties. If they get a broad knowledge of their science at all, it is quite usually through the medium of popular exposition. In this connection we may recall the frank statement of the late Professor P. G. TAIT: "I have abstained from reading the details of any investigation (be its author who he may) which seemed to me to be unnecessarily complex. Such a course has inevitably certain disadvantages, but its manifest advantages far outweigh them."

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD AT THE LICK OBSERVATORY, JUNE 14, 1902, AT 9:15 P. M.

President PERRINE presided, and Dr. TOWNLEY was appointed temporary Secretary. A quorum was present. The minutes of the last meeting were approved as printed.

Mr. JOHN PATTON, of Baltimore, Md., was elected a life member of the Society.

A report of the Committee on Membership, appointed at the last annual meeting, was presented and read by the Secretary. Action on the report was deferred.

A communication from Professor M. McNEILL, concerning the printing of planetary notes, was read and referred to the Publication Committee with power to act.

A communication from the chairman of the Publication Committee relating to the printing of the ***Publications*** was presented and read. After discussion, a motion was adopted directing the President of the Society to secure amendments to the present printing contract to insure greater promptness in publication.

The President announced gifts to the Society from Mr. WILLIAM ALVORD and from Mr. WM. M. PIERSON.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. C. D. Perrine	*President*
Mr. S. D. Townley	*First Vice-President*
Miss R. O'Halloran	*Second Vice-President*
Mr. Chas. S. Cushing	*Third Vice-President*
Mr. R. G. Aitken Mr. F. R. Ziel	*Secretaries*
Mr. F. R. Ziel	*Treasurer*

Board of Directors—Messrs. Aitken, Babcock, Campbell, Cushing, Leuschner, Molera, Miss O'Halloran, Messrs. Perrine, Pierson, Townley, Ziel.

Finance Committee—Messrs. Pierson, Cushing, Babcock.

Committee on Publication—Messrs. Aitken, Galloway, Schlesinger.

Library Committee—Mr. Townley, Miss O'Halloran, Mr. Brasch.

Committee on the Comet-Medal—Messrs. Campbell (*ex-officio*), Pierson, Burckhalter.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. Ruthven W. Pike.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. Felipe Valle.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)

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PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME XIV.
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1902.

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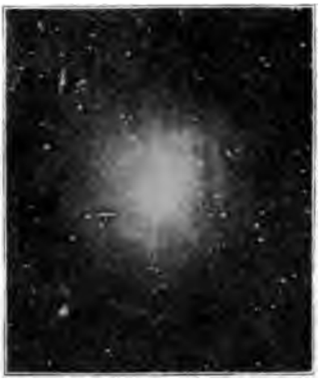
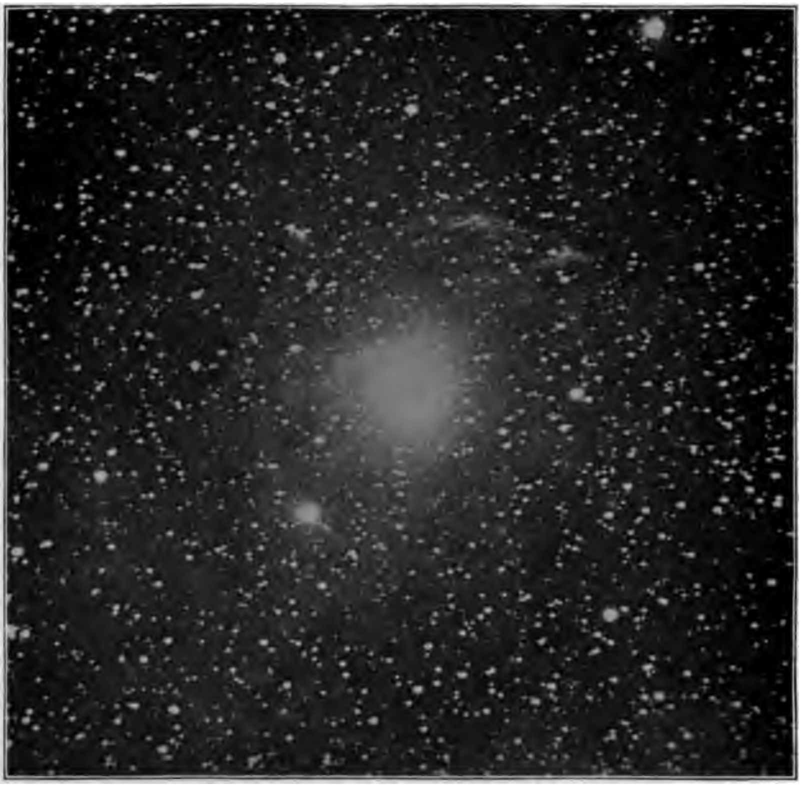
THE NEBULOSITY AROUND NOVA PERSEI.



From a negative made with the Crossley Reflector of the Lick Observatory on March 29, 1901. Exposure 10 min.



From a negative made with the Crossley Reflector of the Lick Observatory *on November* 7 and 8, 1901. Exposure 7 h. 19 m.

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PHOTOGRAPHS OF THE NEBULOSITY SURROUNDING *NOVA PERSEI.*

By C. D. PERRINE.

The accompanying illustrations of the faint nebulosity around *Nova Persei* are direct photographic reproductions of negatives obtained with the Crossley reflector of the Lick Observatory. These plates have been enlarged to two and one-quarter diameters, and the contrasts very much strengthened by successive copyings of the original negatives. The scale of the illustrations is $1^{mm} = 17''$. They have been selected from the series of eleven negatives which show this faint nebulosity. The principal movements and changes which have occurred are plainly visible.

The top of each plate is south.

The plate of March 29, 1901, shows the principal ring of nebulosity, which was visible on the photograph taken at that time. It is not quite continuous on the reproduction, but the brightest portions can easily be seen. A bubble in the glass of the original negative causes a defect in this ring on the west side. Some traces of the inner ring are to be seen, involved in the diffraction rings of the star. A faint, narrow arc of nebula can be made out in the northeast quadrant at a distance of 5′ from the *Nova.*

The photograph of November 12-13, 1901, shows the inner region of nebulosity much the best of any of the negatives. A great amount of structure is to be seen in all parts of this bright ring. The brightest condensations are to the south and southeast. It was the displacement of these masses which led to the detection of the rapid motion in this entire ring of nebulosity. The diameter of this bright ring is 15′.

Outside of this bright ring is another region of about 30′ diameter, which is filled with very faint nebulosity showing some structure. Two arcs of considerable length can be traced near the outer edge of this region to the south and southeast.

There are two defects in this plate due to scratches in the glass of the original negative.

The last illustration is from the photograph taken on the nights of January 31 and February 2, 1902. The inner ring has faded very much in the interval, and shows the bright mass of nebulosity nearest to the *Nova* to a better advantage. The principal features of this inner ring are still to be traced, but with less ease than on the photograph of November. The arrow-shaped mass, A, to the southeast is conspicuous. A comparison of the plates will show what great changes it has undergone both in position and structure in the interval of about twelve weeks. To the southwest and north, near the edges of the plate, are to be seen the wisps of nebulosity which have made their appearance since the photographs of November. These masses are found to be in motion, and have been increasing in brightness, while other portions of the nebula have been fading.

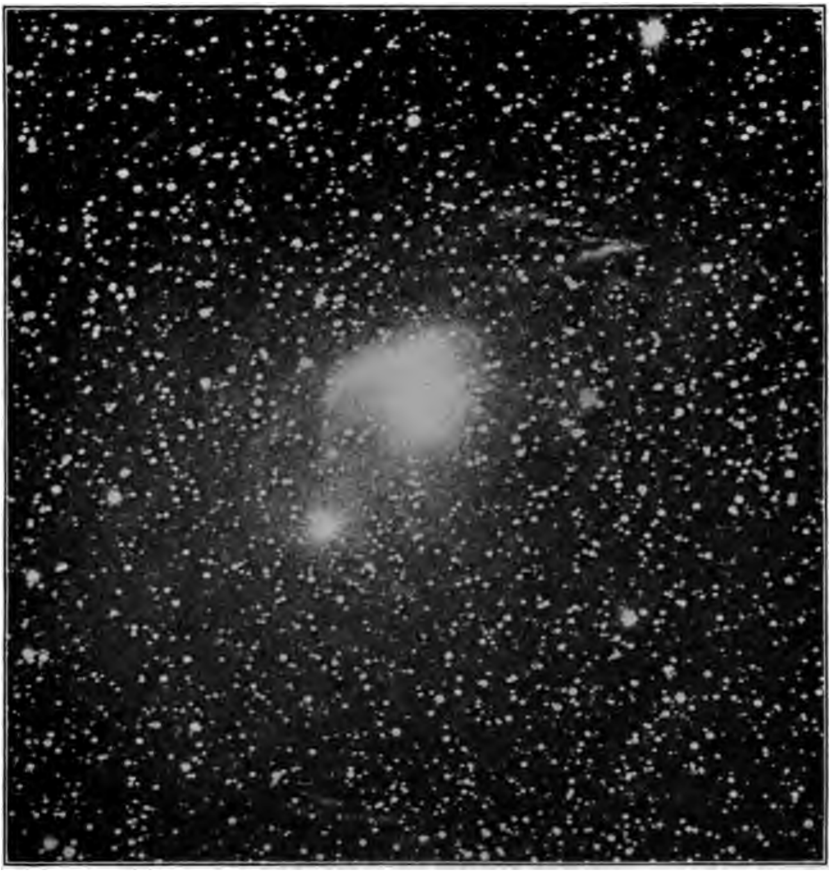
The phenomena observed in this nebulosity are very perplexing, and so far no theory seems to account satisfactorily for all the changes observed.

In March a negative was secured of the nebula with a double-image prism for the purpose of detecting any polarized light. The result is not entirely conclusive, but indicates that there is little or no polarization in the light of the only two masses which were bright enough to record themselves on the negative.

The negative of March 29, 1901, was taken by Messrs. H. K. PALMER and C. G. DALL. The others were obtained by the writer with the assistance of Messrs. H. K. PALMER and JOEL STEBBINS.

MT. HAMILTON, CALIFORNIA, July 25, 1902.

THE NEBULOSITY AROUND NOVA PERSEI.



From a negative made with the Crossley Reflector of the Lick Observatory on January 31 and February 2, 1902. Exposure 9 h. 45 min.

THE ORBIT OF β *DELPHINI.*

By R. G. Aitken.

This investigation was undertaken to determine whether the observations of a close and difficult double star are sufficiently accurate to make it worth while to correct the elements of its approximate orbit by differential methods. Such methods have been applied in researches on the orbits of some of the moderately easy binary and ternary systems, as, for example, in Seeliger's classic memoirs on *Zeta Cancri*. But the orbits of the more difficult binaries have generally been based in part or wholly upon the graphic construction of the apparent ellipse, though the resulting elements have occasionally been improved by the use of Klinkerfues's very convenient method of six position-angles.

The system of *β Delphini* seemed well adapted for such an investigation. Though discovered by Burnham as recently as 1873, it has already completed a revolution. The maximum distance does not reach 0″.7, and its minimum distance, about 0″.2, does not fall below the resolving power of our larger telescopes. The pair has been, accordingly, well observed by all the leading double-star observers of the last quarter century, and a number of orbits have been computed. The two most recent ones, by See in 1895, and Burnham in 1898, are very similar in all their elements except the length of the semiaxis major.

The first step in the present investigation was to compare with these two orbits the observations of the star collected in Burnham's General Catalogue of his double stars. The comparison was made by drawing interpolating curves for the computed angles and distances derived from either orbit, and plotting the observed positions on the same scale. There seemed but little choice between the two curves for position-angles, See's representing the observed positions somewhat better at the two extremities, Burnham's those in the middle portion. But Burnham's distance-curve represents the distance-measures of the best observers far better than does See's.

Using See's elements as a basis, I next computed the following set of elements by KLINKERFUES's method of six position-angles:—

SYSTEM I.

$P = 27.94$ years
$T = 1883.230$
$e = 0.363$
$a = 0''.475$
$\Omega = 179^\circ.10$
$i = 61\ .75$
$\lambda = 352\ .80$

Interpolating curves were constructed from these elements, and the individual observations to 1902 compared with them, the measures having been taken from original sources. In this connection I wish to express my hearty thanks to Professor SCHIAPARELLI, who kindly sent me the full details of his fine series of measures of this pair.

Angle-measures that gave residuals exceeding 10° as the result of this comparison were rejected, unless the distance at the time of observation was as small as 0''.25. In this case the limit was set at 15°. Individual distance-measures were rejected only when they differed by 0''.2 from the computed, but an observer's mean result for any year was given weight zero if it differed by 0''.15 from the computed distances. The annual means were then formed by combining the measures of the various observers, assigning weights to each, depending in part upon the number of observations and in part upon the aperture of the telescope used.

When these annual means were compared* with the elements given above, it appeared that the distances were satisfactorily represented, but the residuals in angle seemed to show systematic deviations. The measures of each observer had already been examined for systematic errors of observation, but only two series of observations—SCHIAPARELLI's and BURNHAM's—were of sufficient extent to afford a basis for deriving reliable corrections for such errors, and their measures did not indicate appreciable errors of this kind.

A least-square solution therefore seemed unwarranted, and it was considered better to combine the annual means to form

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*The details of this comparison and of the comparison of BURNHAM's and SCHIAPARELLI's observed positions with those derived from Elements II are given in Lick Observatory *Bulletin* No. 26.

six normal position-angles and again apply KLINKERFUES'S method.

These normal angles, with dates and residuals, are as follows:—

DATE.	Mean Anomaly. System I.	$\Delta\theta$ (o–c) System I.	Normal Angle.	Weight.	$\Delta\theta$ (o–c) System II.
1876.246	270°	— 1°.26	22°.64	22	— 1°.58
1882.066	345	+ 2 .45	159 .45	11	+ 1 .49
1885.946	35	— 0 .88	220 .94	15	— 4 .37
1888.662	70	+ 2 .56	300 .86	30	+ 1 .18
18 .318	130	— 0 .60	341 .27	70	— 0 .47
1899.526	210	+ 1 .40	364 .33	77	+ 0 .93

The elements resulting from this new solution are:—

SYSTEM II.

$P = 27.66$ years
$T = 1883.10$
$e = 0.363$
$a = 0''.475$
$\Omega = 178^\circ.90$
$i = 60\ .90$
$\lambda = 351\ .95$

The value of *a* was derived from several normal values of the observed distances based upon measures by BURNHAM, BARNARD, SCHIAPARELLI, COMSTOCK, HUSSEY, and AITKEN.

The last column in the table shows that these new elements represent all the normal places, except the first and third, better than System I. These two places—and the second as well—have much less weight than the last three; and it is to be remembered that they are based in large part upon measures with small telescopes. Considering this fact and the small apparent separation of the components of *β Delphini* in those years, we should expect larger errors in the measures made before 1887 than in the later ones.

I therefore regard System II as satisfactory, so far as the representation of the data at hand is concerned, and I think that the use of differential formulæ and a least-square solution will be of little service in improving these elements until more extended series of measures are available.

As the apparent orbital motion of this pair will increase rapidly during the next few years, I append an ephemeris, giving the relative positions of the two components according to Elements II for every tenth degree of mean anomaly to the date of the next periastron passage.

EPHEMERIS.

DATE.	M.	θ	ρ
1903.077	260°	18°.6	0″.48
1903.845	270	23 .6	0 .43
1904.613	280	30 .1	0 .37
1905.382	290	38 .9	0 .31
1906.150	300	51 .8	0 .26
1906.918	310	71 .2	0 .21
1907.687	320	97 .8	0 .19
1908.455	330	125 .7	0 .20
1909.223	340	147 .3	0 .24
1909.992	350	162 .8	0 .28
1910.760	360	175 .0	0 .30

September 7, 1902.

PLANETARY PHENOMENA FOR NOVEMBER AND DECEMBER, 1902.

By MALCOLM MCNEILL.

NOVEMBER.

Mercury is a morning star throughout the month, coming to greatest west elongation on the morning of November 4th. It will then rise about an hour and a half before sunrise, and until about November 20th it will be above the horizon at least an hour before the Sun. The present west elongation is only 19° (less by 8° than the east elongation of September), due to the fact that the planet passed its perihelion on October 24th, only a week before the time of greatest elongation.

Venus has been morning star since February 14th, but now comes to superior conjunction, and becomes an evening star on November 28th. It is almost too near the Sun to be seen at any time during the month.

Mars rises not long after midnight, coming to the horizon about one minute earlier each night. It moves 15° eastward and southward through *Leo* into *Virgo*. No very bright stars are near its path, but toward the close of the month it is somewhat to the west of *β Virginis*. It is beginning to approach the Earth quite rapidly, and consequently is beginning to be much brighter; but it is still faint as compared with its appearance when it is near opposition.

Jupiter is still in good position for early evening observation, but it sets shortly after nine o'clock at the close of the month. It is in quadrature with the Sun on November 1st, and during the month moves about 4° eastward and 1° northward in the constellation *Capricorn.*

Saturn is getting rather close to the Sun for good observation, although it does not set until about 8 P. M. at the close of the month. It is also in *Capricorn,* about 17° west of *Jupiter,* and moves more than 2° eastward during the month.

Uranus is still closer to the Sun than *Saturn* is, and in the same quarter of the heavens. It is entirely too low for such a faint object to be seen in the evening twilight. It moves about 2° eastward in the constellation *Ophiuchus.*

Neptune rises shortly after sunset. It is in the western part of *Gemini.*

DECEMBER.

The Sun reaches the winter solstice and winter begins December 22d, 10 A. M. Pacific time.

Mercury begins the month as morning star, too near the Sun to be seen, passes superior conjunction and becomes an evening star on December 12th, but hardly reaches a sufficient distance from the Sun to be visible to the naked eye until after the close of the month. It is in conjunction with *Venus* about midnight on December 21st, but both planets are then too near the Sun to be visible to the naked eye.

Venus becomes an evening star on November 28th, but it is rather slow about moving away from the Sun, reaching a distance of only about 8° at the end of the month. As it is also on the far side of its orbit beyond the Sun, it will be much less bright than usual, and it will hardly be possible to see it unless under exceptionally good conditions of the atmosphere.

Mars will rise before midnight at the close of the month. It moves eastward about 13° and southward about 5° in the constellation *Virgo,* and is beginning to slacken up its speed among the stars. It will begin to retrograde early in 1903. Its distance in millions of miles from the Earth diminishes from 145 to 118, and consequently it gains nearly one half in brightness during the month. So it has become a fairly conspicuous object.

Jupiter sets before 8 P. M. at the close of the month, and is therefore getting rather low for telescopic observation, but it is still fairly seen by the naked eye, and is in fact the most conspicuous object in that part of the evening sky. It moves 6° eastward during the month, but still remains in *Capricorn*.

Saturn is still lower than *Jupiter*, and at the close of the month sets less than an hour and a half after sunset. With its low altitude in the evening twilight, it is no longer a conspicuous object, but it is still far enough away from the Sun to be identified without aid from a telescope. It is also in *Capricorn*, and moves eastward more than 3° during the month.

Uranus comes to conjunction with the Sun on December 14th, changing from an evening to a morning star, but is too faint to be made out even with a telescope at such a short distance from the Sun as it has at any time during the month.

Neptune is in opposition with the Sun on December 24th, and is above the horizon practically the entire night.

NOVEMBER–DECEMBER, 1902.

PHASES OF THE MOON, P. S. T.

First Quarter, . . .	Nov. 8,	4^h	30^m	A. M.
Full Moon, . . .	Nov. 15,	9	6	
Last Quarter, . . .	Nov. 21,	11	47	P. M.
New Moon, . . .	Nov. 29,	6	4	
First Quarter, . . .	Dec. 7,	10	26	
Full Moon, . . .	Dec. 14,	7	47	
Last Quarter, . . .	Dec. 21,	Noon.		
New Moon, . . .	Dec. 29,	1	25	P. M.

THE SUN.

1902.	R. A.	Declination.	Rises.	Transits.	Sets.
Nov. 1,	$14^h\ 23^m$	$-14^\circ\ 13'$	$6^h\ 33^m$ A.M.	$11^h\ 44^m$ A.M.	$4^h 55^m$ P.M.
11,	15 3	— 17 15	6 44	11 44	4 44
21,	15 44	— 19 47	6 56	11 46	4 36
Dec. 1,	16 26	— 21 43	7 7	11 49	4 31
11,	17 10	— 22 57	7 16	11 53	4 30
21,	17 54	— 23 27	7 24	11 58	4 32
31,	18 39	— 23 9	7 27	12 3 P.M.	4 39

Mercury.

Nov.	1,	13 17	− 5 57	4 57 A.M.	10 37 A.M.	4 17 P.M.
	11,	13 59	−10 0	5 14	10 40	4 6
	21,	14 57	−15 44	5 54	10 59	4 4
Dec.	1,	16 1	−20 41	6 37	11 23	4 9
	11,	17 7	−24 1	7 18	11 50	4 22
	21,	18 17	−25 17	7 53	12 20 P.M.	4 47
	31,	19 27	−24 07	8 20	12 52	5 24

Venus.

Nov.	1,	13 58	−10 49	5 56 A.M.	11 19 A.M.	4 42 P.M.
	11,	14 47	−15 9	6 20	11 28	4 36
	21,	15 37	−18 50	6 46	11 39	4 32
Dec.	1,	16 29	−21 39	7 8	11 51	4 34
	11,	17 23	−23 25	7 31	12 6 P.M.	4 41
	21,	18 18	−24 1	7 49	12 21	4 53
	31,	19 13	−23 22	8 2	12 37	5 12

Mars.

Nov.	1,	10 29	+11 12	1 11 A.M.	7 50 A.M.	2 29 P.M.
	11,	10 51	+ 9 13	1 0	7 32	2 4
	21,	11 11	+ 7 15	12 48	7 13	1 38
Dec.	1,	11 30	+ 5 20	12 35	6 53	1 11
	11,	11 49	+ 3 31	12 20	6 32	12 44
	21,	12 6	+ 1 48	12 4	6 10	12 16
	31,	12 22	+ 0 16	11 45 P.M.	5 46	11 47 A.M.

Jupiter.

Nov.	1,	20 45	−18 56	1 12 P.M.	6 05 P.M.	10 58 P.M.
Dec.	1,	21 1	−17 51	11 26 A.M.	4 23	9 20
Jan.	1,	21 25	−16 5	9 40	2 44	7 48

Saturn.

Nov.	1,	19 36	−21 49	12 14 P.M.	4 56 P.M.	9 38 P.M.
Dec.	1,	19 46	−21 17	10 24 A.M.	3 8	7 52
Jan.	1,	20 0	−20 52	8 35	1 20	6 5

Uranus.

Nov.	1,	17 12	−23 5	9 55 A.M.	2 32 P.M.	7 9 P.M.
Dec.	1,	17 19	−23 13	8 6	12 42	5 18
Jan.	1,	17 28	−23 21	6 12	10 47 A.M.	3 22

Neptune.

Nov.	1,	6 15	+22 16	8 16 P.M.	3 37 A.M.	10 58 A.M.
Dec.	1,	6 13	+22 16	6 16	1 37	8 58
Jan.	1,	6 9	+22 17	4 6	11 27 P.M.	6 48

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Of right-hand limb as seen in an inverting telescope.)

II, D,	Nov.	1,	7h	33m P.M.	II, R,	Dec.	3,	7h	26m P.M.
I, R,		3,	7	57	I, R,		5,	4	36
IV, D,		4,	6	44	I, R,		12,	6	31
IV, R,		4,	11	28	III, D,		19,	1	41
III, R,		6,	5	5	III, R,		19,	5	13
II, R,		8,	10	12	I, R,		19,	8	26
I, R,		10,	9	53	II, R,		21,	2	2
I, R,		12,	4	21	I, R,		21,	2	55
III, D,		13,	5	34	III, D,		26,	5	42
III, R,		13,	9	6	III, R,		26,	9	14
I, R,		19,	6	17	II, R,		28,	4	41
III, D,		20,	9	35	I, R,		28,	4	50
IV, R,		21,	5	40					
II, R,		26,	4	48					
I, R,		28,	2	41					

THE SEARCH FOR AN INTRA-MERCURIAL PLANET AT THE TOTAL SOLAR ECLIPSE OF 1901, MAY 18.

By C. D. PERRINE.

The considerable motion of the line of apsides of *Mercury's* orbit, found by LEVERRIER and others, cannot be explained by the attraction of the known bodies in the system, but would be fully accounted for by a planet or ring of planets between *Mercury* and the Sun.

The question is one which has attracted more or less attention from astronomers for over a century, and announcements have been made at various times of the supposed discoveries of such bodies. None of these announcements have ever been verified, however.

The solution of the problem is of peculiar difficulty. The necessary observations are possible only during the few minutes of a total eclipse, when the Sun's disk is entirely hidden. At any other time it would be impossible to detect an object very much fainter than *Mercury*.

The early searches at total eclipses were all made visually, and it was necessary to memorize the position and brightness of all the brighter stars in the region to be examined. The liability to mistake in the identification of stars was thus very great. Several of the supposed discoveries are probably due to this cause.

Searches by visual methods at a number of eclipses rendered it almost certain that there were no such bodies as bright as the third, and possibly the fourth, magnitude. But as to fainter objects there was no evidence whatever.

Since the introduction of the rapid dry-plate into astronomical work, it has become possible to attempt an adequate search for such bodies.

The first attempt, to my knowledge, to solve this problem with cameras of considerable focal length was during the eclipse of May 28, 1900. No definite results seem to have been obtained at that eclipse, however.

The great duration of totality (6½ minutes) in 1901 was very favorable for an intra-Mercurial planet search. The observations made in Sumatra for this purpose were described in the account of the Crocker Expedition from the Lick Observatory, published in No. 81 of the *Publications*. A re-examination of these plates has just been completed under more favorable conditions and has resulted in finding many fainter stars and some star-images on all of the plates.

Following is a summary of the results of the examination:—

No. of Plates.	STAR IMAGES.			REMARKS.
	Original Search.	Added by Re-examination.	Total Number.	
A_1 B_1	29	21	50	Faintest stars = one each of 9.1, 9.2, and 9.3 visual magnitude.
C_1 D_1	37	14	51	Faintest stars = two each of 8.6 and 9.0 visual magnitude.
A_2 B_2	26	9	35	Faintest stars = one each of 8.7 and 8.8 visual magnitude.
C_2 D_2	0	26	26	Faintest stars = three of 8.3, one each of 8.6 and 8.7 visual magnitude.
A_3 B_3	0	3	3	One star each of 6.0, 6.2, and 6.5 visual magnitude. *Mercury* and *Venus* are bright objects on the plates.
C_3 D_3	0	5	5	One star each of 4.0, 5.2, and 6.5 visual magnitude and two of 6.0 visual magnitude.
Total.	92	78	170	

Four out of the six regions covered by the photographs show stars from 8.7 to 9.3 visual magnitude. These were the first two sets of exposures. The clouds became thicker toward the end of totality, so that the set of exposures made then fails to show as faint stars. They, however, contain stars from 6.0 to 6.5 magnitude. Only two stars in the entire region, which were brighter than 6.0 visual magnitude, failed to record themselves on all of the plates. One of these was 5.0, the other 5.1 visual magnitude. According to the Draper Catalogue, the photographic magnitudes of these stars are 5.2 and 6.1, the former being a red star.

As the faintest stars recorded on the negatives are those which, in general, are more strongly actinic than a planetary body, it is necessary to make some allowance for this difference in deducing the limiting (visual) magnitude of the search. It seems probable that this difference would usually not exceed one magnitude. Hence if all the stars of 6.0 visual magnitude were recorded on the plates, a planet of 5.0 magnitude should be visible. The same criterion would indicate that in two thirds of the region searched, where stars of 8.7 to 9.3 magnitude were photographed, a planet as bright as 7¾ or 8.0 magnitude should have been recorded.

There is therefore little probability that any planet as bright as 5.0 magnitude exists in the region searched. While the clouds prevented the search from being definite to a much fainter magnitude, it is hardly possible that a ring of planets as bright as 8th magnitude can exist without some of them having been found.

From observations of the brightness of the four principal asteroids made at Harvard College Observatory and the measures of their diameters made by BARNARD at the Lick Observatory, it is found that such a body 300 miles in diameter appears on the average as a star of the 8.0 magnitude when seen from the Earth at opposition. If such a body were removed to the greatest probable distance from the Sun of an intra-Mercurial planet, it would appear to an observer on the Earth more than 110 times as bright, a difference ,of over five magnitudes. Hence we find that an intra-Mercurial planet to be of 5.0 magnitude would have to be only 75 miles in diameter, and one of 8.0 magnitude but 30 miles in diameter.

The perturbations in the motion of *Mercury* would require a mass of matter about half as great as that of the planet itself. It would therefore take one million intra-Mercurial planets 30 miles in diameter, and as dense as *Mercury*, to cause the observed disturbances.

The observations made at this eclipse, although very much interfered with by the clouds, indicate that there are probably no bodies of appreciable size in the region close about the Sun, and that the cause of the disturbance in the motion of *Mercury* must be sought elsewhere.

The suggestion has also been made that these perturbations might be caused by a ring of bodies between *Mercury* and *Venus*. If this were true, it would seem that some effect should be observed in the motion of *Venus*.

Perhaps the finely divided matter composing the Zodiacal Light may be sufficient to cause these perturbations.

MT. HAMILTON, CALIFORNIA, August 27, 1902.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

THE OBSERVATORY INSTRUMENT-MAKING SHOPS.

A generation ago the astronomer ordered his telescope and expected it to meet all his requirements. This is no longer sufficient. The wonderful developments of our science call for special instruments to do special work, and the so-called universal instrument is out of date. The successful instrument must have the maximum efficiency in the problem to be solved. This is especially true in investigations along astrophysical lines. Every observatory of our class requires an instrument-making shop near at hand. This need is very pressing here, on account of our unusual isolation.

The shops at the Lick Observatory were entirely inadequate for their purpose. Up to one year ago, the equipment consisted of two small antiquated foot-power lathes, an antiquated hand-drill, files, etc., and the carpenter's hand-tools. The quantity of construction possible by their means was small, many vital parts of the instruments could not be made at all, vexatious delays in construction elsewhere were frequent, and our plans were rapidly falling in arrears to such an extent that the efficiency of the Observatory suffered severely. I therefore decided to devote the first available funds to the improvement of the machine-shops.

The carpenter-shop, paint-shop, and forge occupied adjoining rooms in a small brick building near the great dome, constructed by the Lick Trust. The paint-shop was removed to a distant isolated building, both to diminish risks from fire and to increase the space in the carpenter-shop. The inside walls of the forge-room were likewise removed. The resulting carpenter-shop is 20 × 26 feet inside. An addition to this shop was built by the Observatory workmen in 1891 (inside dimensions, 25 x 33 feet) from brick left in the orignal Lick Trust kilns. This room had been used for storage, for the metal-working shop, and for a steam boiler and engine employed in charging storage-batteries and in sawing the observatory wood. The engine and wood-saw were removed to a small brick building in 1901, to the east of the barn, and storage space has been found elsewhere. The rearranged room admirably meets the requirements of a complete instrument-making shop on the small scale desired. A Foos four-horse-power gasoline engine was installed in the shop in place of the steam engine. It drives the metal- and wood-working machines described below. It has the usual advantages of such an engine: it is always ready to start without waiting for steam to rise; the expense of fuel is small; it does not need the attention of a fireman; and it does not heat the work-room unduly.

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* Lick Astronomical Department of the University of California.

A Brown & Sharpe universal milling machine, a Brown & Sharpe tool-grinding machine, a modern wood-turning lathe, a wood rip-saw, and an emery grinder were purchased in 1901. The old foot-lathes were modified to adapt them to power, and it is planned to convert one of them into a grinding machine. The necessary shafting, pulleys, belting, attachments, and small tools were likewise provided. The gasoline engine also drives the dynamo.

The thoughtful generosity of Mrs. HEARST has enabled me to arrange for the completion of the shops without the delay that I feared must occur, by purchasing a modern lathe of fourteen-inch swing and eight-foot bed, with all necessary attachments; a power drill; a power saw for cutting metal; a cross-cut saw for wood; a wood-shaper; a small tempering and reducing furnace; and many minor tools.

It is planned to have all heavy work done elsewhere. For this reason, metal-shapers and other similar tools have been omitted from the equipment.

The press of work resulting from the remounting of the Crossley reflector, from the reconstruction of the Mills spectrograph, for which Mr. MILLS has provided funds, and from the construction of a modern one-prism spectrograph from the Draper Fund of the National Academy of Sciences, has made it necessary to employ temporarily a second instrument-maker, with salary paid from the two funds mentioned.

W. W. CAMPBELL.

A NEW RAPID BINARY STAR.

Recent measures of the double star A. 88 = Ll. 34524, which was discovered with the 36-inch telescope on June 2, 1900, have confirmed the fact suggested by the earlier measures that this pair is in rapid orbital motion. The mean results of measures for the three years are:—

1900.46	353°.2	0″.14	6.9–7.1	3^n	36-inch
1901.56	338 .3	0 .14		3	36-inch
1902.66	318 .1	0 .12		3	36-inch

The star's position for 1900.0 is:—

R.A. $18^h\ 33^m\ 9^s$; Decl. — 3° 17′

September 9, 1902.

R. G. AITKEN.

THE DISCOVERY OF 83 *AQUARII* AS A DOUBLE STAR.

In the course of my search for new double stars I examined the star 83 *Aquarii* with the 12-inch telescope on the night of July 29, 1902, and noted that it was apparently elongated. On August 16th an examination with the 36-inch telescope confirmed the fact of its duplicity. Measures have been obtained as follows:—

	θ	ρ	Seeing.	Eye-piece.	
1902.624	55°.8	0″.21	2+	1500	36-inch
.640	63 .8	0 .16	3	1500	36-inch
.643	62 .7	0 .20	3	1500	36-inch
.660	61 .5	0 .18	3	1500	36-inch
1902.64	61°.0	0″.19			

The two components are sensibly equal in brightness, each being estimated as of the sixth magnitude.

It is already evident that this pair of stars forms a physical system, for according to AUWERS it has an annual proper motion of 0″.023 in 17°.5. If this were not common to both components, the pair would have been an easy one in STRUVE'S time, and would have been listed by him when he catalogued 83 and 84 *Aquarii* as the wide pair $\Sigma\ 59^{\mathrm{I}}$.

The position of the star for 1900.0 is—

R.A. $22^h\ 59^m\ 57^s$; Decl. — 8° 14′

September 9, 1902.

R. G. AITKEN.

COMET *b* 1902 (PERRINE).

This comet was discovered in the morning of September 1st (civil time), in the constellation *Perseus.* The position of the comet at the time of discovery was—

$$\text{R.A. } 3^{\text{h}}\ 17^{\text{m}}\ 49^{\text{s}};\ \text{Decl.} + 34^\circ\ 38'\ 47''$$

It was of about the 9th magnitude, with a nucleus of the 10½ or 11th magnitude. The head of the comet was 4′ or 5′ in diameter, and a very short tail extended toward the southwest.

Observations were secured on the morning of discovery and the two subsequent mornings, from which I have computed the following parabolic elements:—

$$T = 1902,\ \text{November } 23.4720\ \text{G. M. T.}$$

$$\left.\begin{aligned}\omega &= 153^\circ\ 25'\ 46''\\ \Omega &= 49\ \ 56\ \ 10\\ i &= 156\ \ 54\ \ 22\end{aligned}\right\}\ 1902.0$$

$$\log q = 9.60424$$

Residuals, Obs.—Comp.

$$\Delta\,\lambda'\cos\beta'\ \ + 4''$$
$$\Delta\,\beta'\ \ \ \ - 3$$

An ephemeris from these elements shows that the comet will be well placed in the northern sky during September and October, and that it will increase very much in brightness.

1902, September 4. C. D. PERRINE.

DISCOVERY OF TWO VARIABLE STARS IN THE NEBULA N. G. C. 7023.

This is one of the nebulæ on Professor KEELER's programme of work for the Crossley reflector. A comparison of two negatives, taken on November 7, 1901, and August 27, 1902, led to the discovery of two faint variable stars within the nebulosity. Their positions from the central star in the nebula are as follows:—

	p	*s*
A	6°.2	107″.1
B	138 .6	87 .4

Another photograph was taken on September 1st, and as a slight but certain change is noticeable in the interval of five days, the periods are probably comparatively short.

The following magnitudes have been assigned to the variables:—

		a	b
1901.	November 7	[illegible]	[illegible]
1902.	August 5	[illegible]	[illegible]
	September 1	[illegible]	[illegible]

So far as I am aware no variable stars have heretofore been found in the nebulæ.

N. G. C. 7023 is an especially interesting nebula from its suggestive location in a region comparatively devoid of stars. The nebula is about 15' across, and consists of irregular streamers and masses of nebulosity coiled about a 7th-magnitude star.

Mr. Joel Stebbins and Mr. R. H. Curtiss, Fellows in Astronomy at the Lick Observatory, gave efficient assistance in the taking of the photographs.

C. D. Perrine.

Mt. Hamilton, California, 1902, September 5.

ASTRONOMICAL TELEGRAMS.

(*Translations.*)

Lick Observatory, Mt. Hamilton, Cal.,

Sept. 1, 1902.

To Harvard College Observatory: (Sent 11:30 A. M.)

A comet was discovered by Perrine on Sept. 1.0103 G. M. T.; in R. A. 3h 17m 49s.4; Decl. — 34° 38' 47". Its daily motion is — 10' in R. A. and — 25' in Decl. Its physical appearance is as follows: Slightly elongated, 4' in diameter, 9th magnitude, with tolerably well-defined nucleus, and tail less than 30'.

(Signed) W. W. Campbell.

Lick Observatory, Mt. Hamilton, Cal.,

Sept. 2, 1902.

To Harvard College Observatory: (Sent 10 A. M.)

Comet Perrine was observed by Perrine on Sept. 1.9433 G. M. T.; in R. A. 3h 17m 3s.0; Decl. + 35° 0' 34".

(Signed) W. W. Campbell.

Lick Observatory, Mt. Hamilton, Cal.,

To Harvard College Observatory: Sept, 3, 1902.

To Students' Observatory, Berkeley, Cal.: (Sent 10 A. M.)

Comet Perrine was observed by Perrine on Sept. 2.8889 G. M. T.; in R. A. 3h 16m 9s.6; Decl. + 35° 23' 35".

(Signed) W. W. Campbell.

LICK OBSERVATORY, MT. HAMILTON, CAL.,
Sept. 3, 1902.

To Harvard College Observatory: (Sent 9:00 P. M.)

Elements and ephemeris of Comet *b* were computed by PERRINE as follows:—

$$\begin{array}{rl} T = & 1902,\ \text{November } 24.47\ \text{G. M. T.} \\ \omega = & 153^\circ\ 26' \\ \Omega = & 49\ \ 56 \\ i = & 156\ \ 54 \end{array} \left.\begin{array}{l} \\ \\ \\ \\ \end{array}\right\} 1902.0$$

Natural $q = 0.4020$

The brightness of the comet on Sept. 5 will be 1.5, on Sept. 18, 4.5.

(Signed) W. W. CAMPBELL.

[The ephemeris at 4-day intervals from Sept. 6 to Sept. 18 is here omitted.]

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in the work of this department. Communications to this end may be sent to FRANK SCHLESINGER, International Latitude Observatory, Ukiah, California.

Early Knowledge of the Distances of the Stars.—The impression is quite general, but nevertheless erroneous, that astronomy had to wait until the nineteenth century for proper conceptions concerning the immensity of stellar distances. It is true that not until then were instruments perfect enough to enable actual measures of parallax to be made; but as early as the beginning of the eighteenth century the *order* of stellar distances was correctly inferred from methods not unlike and not inferior to those sometimes used at the present time for the same purpose.

In his recent book on "The Stars," NEWCOMB has the following paragraph (page 142):—

> "Considerations drawn from photometry were also lost sight of, because that art was still undeveloped. KEPLER saw that the Sun might well be of the nature of a star; in fact, that the stars were probably suns. Had he and his contemporaries known that the light of the Sun was more than ten thousand million times that of a bright star, they would have seen that if placed at one hundred thousand times its present distance the Sun would still shine as a bright star. If, then, the stars are as bright as the Sun, they must be one hundred thousand times as far away, and their annual parallax would then have been too small for detection with the instruments of the time. Such considerations as this would have removed the whole difficulty."

This method of estimating the distances of stars was originally proposed by JAMES GREGORY, who was born eight years after KEPLER's death. HUYGENS (1629-1695) was the first to use it, and he concluded that *Sirius* (presumably one of the nearest of the stars) has a parallax of about 7″; a result which is too great, partly because *Sirius* is intrinsically brighter than the Sun, and partly because of the difficulty of estimating the relative brightness of such greatly different luminaries. This latter difficulty was overcome with great ingenuity by NEWTON (1642-1727), in whose *Principia* (page 547, MOTTE's Translation) will be found these words:—

> "The disk of *Saturn*, which is only 17″ or 18″ in diameter, receives but about $\frac{1}{2,100,000,000}$ of the Sun's light; for so much less is that disk than the whole spherical surface of the orb* of *Saturn*. Now, if we suppose

---

* That is, a sphere having a radius equal to the distance of *Saturn* from the Sun.

> *Saturn* to reflect about one quarter of this light, the whole light reflected from its illuminated hemisphere will be about $\frac{1}{4,200,000,000}$ of the whole light emitted from the Sun's hemisphere; and, therefore, since light is rarefied in the duplicate ratio of the distance from the luminous body, if the Sun was $10,000\sqrt{42}$ times more distant than *Saturn*, it would yet appear as lucid as *Saturn* now does without its ring, that is, something more lucid than a fixed star of the first magnitude. Let us, therefore, suppose that the distance from which the Sun would shine as a fixed star exceeds that of *Saturn* by about 100,000 times, and its apparent diameter will be 0″.002, and its parallax arising from the annual motion of the Earth 0″.2; and so great will be the distance, the apparent diameter, and the parallax of the fixed stars of the first magnitude, in bulk and light equal to our Sun."

This estimate, made over two hundred years ago, can hardly be improved upon at the present day. It may be worth while to remark that modern measurements of the albedo of *Saturn* show that this planet reflects at least twice the fraction assumed by NEWTON.

Had this paragraph of NEWTON'S received more attention from his contemporaries and successors, it might perhaps have led to more hesitation in announcing large parallaxes and measurable diameters for certain stars. Even so late and so eminent an observer as the elder HERSCHEL thought he could detect the true disks of the brighter stars, and actually published some measures of their angular diameters.

The Tychonic System.—The above note suggests a word concerning TYCHO BRAHE'S system, in which the Sun and the Moon were supposed to revolve around the Earth, and the planets around the Sun. It seems to us that this system has been too severely dealt with by writers on Astronomy, who usually refer to it in such terms as "strange," "grotesque," and "unfortunate." It should be borne in mind that TYCHO'S system, so far as the Sun, Moon, and planets are concerned, is *geometrically* identical with that of COPERNICUS; that is, the relative motions of any two bodies are the same in either system. The greatest obstacle in the way of the general acceptance of the ideas of COPERNICUS was the lack of parallax in the stars. Men were just then striving to realize the great distance of the Sun from the Earth. Small wonder that they should hesitate to believe that this distance is a mere point in comparison with the distances to the stars. TYCHO'S system may therefore be said to fit in better with the observed facts than did that of

COPERNICUS. Especially will this appear to be true when we recall the state of mechanical knowledge at the time. The ideas concerning mechanics were then very vague, even as regards terrestrial phenomena; and the extension of these ideas to the heavens tended rather to disprove than to confirm the motion of the Earth. These considerations must increase our admiration for the genius of COPERNICUS, who was able to see beyond such formidable objections; but at the same time they should make us more lenient toward TYCHO's system, which from the standpoint of a contemporary had much to commend it.

The Rate of a Clock in Constant Temperature and under Constant Pressure.—At the Case Observatory (Cleveland, Ohio) the experiment has been tried of subjecting an astronomical clock to constant pressure and temperature. The whole clock, together with a barometer and a thermometer, is inclosed in an air-tight compartment from which the air may be partly exhausted. By noting the reading of the barometer, and, if necessary, exhausting the air a little further, it is possible to keep the pressure sensibly constant. The whole arrangement is placed in a constant-temperature room. In this instance, the temperature is automatically kept unvaried by means of thermostats. Professor HOWE has a paper in *Astronomical Journal* No. 524 on the performance of this clock. For a period of three months, in which the clock-error was observed sixteen times (rejecting three nights for reasons given), he finds the daily rates to vary at most only $0^s.022$ from the mean. The daily rates were computed by using the observations only in pairs; that is, each night with the following one. This method of computation is, if anything, unfavorable to the clock, as errors of observation have too large an effect on the rates. This is especially true in the present case because the intervals between observations are sometimes quite short —in one case only twenty-two hours. The writer of this note made a least-square solution to see how well the observed clock-errors would satisfy the assumption of a constant rate. He found that the largest residual (observed *minus* computed clock-corrections) was $0^s.3$. Another solution, using only the last two months, during which period the clock-correction had been determined thirteen times, gave no residual so great as $0^s.10$. Even this quantity, remarkably small though it is, cannot all be ascribed to irregularities of the clock; part of it is due to errors of observation and to errors in the almanac places of the stars, different sets having been used on different nights.

An interesting problem occuring in the method of least-squares is the following: What is the probable error of a given function of x, y, z, etc., when the values of the latter have been found from the same least-square solution? If x, y, z, etc., were independent of each other the answer would be quite simple, but it is clear that they are functions of the same observed quantities, and therefore functions of each other. The problem has been treated in its most general form by HELMERT in his *Ausgleichungsrechnung nach der Methode der kleinsten Quadrate* (page 139). In *Astronomical Journal* No. 523 Mr. HERBERT L. RICE gives a new demonstration of the fundamental formula and points out several places where eminent astronomers have been at fault on this point.

A List of New Variables.—The Committee on Variable Stars appointed by the *Astronomische Gesellschaft* has recently reported a list of twenty-four recently discovered variable stars, whose variability has been confirmed. Most of them were discovered by means of photography. Four of the variables are of the *Algol* type; that is, their light is constant, except for a short time at minimum. The list is rather unusual in the faintness of the stars even at maxima. Only one star reaches a magnitude between six and seven, the next brightest being between the eighth and ninth magnitude at its maximum. One star is never brighter than the eleventh magnitude. This would seem to indicate that most of the variables among the brighter stars have already been detected. It must be borne in mind, however, that in the present state of photometry a variable will probably escape detection unless it nearly doubles its light in going from minimum to maximum, or, in other words, unless it varies nearly three quarters of a magnitude or more. No doubt there are many stars which vary only one or two tenths of a magnitude, and quite possibly, when photometers are sufficiently improved, we shall find that a considerable fraction of all the stars are variable to some extent.

It is understood that the discoverer of a minor planet shall assign to it a feminine name. The only exception to this rule is the case of *Eros,* which, on account of its extraordinary orbit, is justly distinguished from others of the family. To find suitable names, with this restriction, for so many planets has overtaxed the ingenuity of the discoverers, until now no interest whatever attaches to the naming of a minor planet. Dr. DELISLE STEWART has, however, given a particularly apt name, *Occlo,* to the planet discovered by him at Arequipa, Peru, in 1901. *Occlo* was the first queen of the Incas, and, according to native mythology, she was the daughter of the Sun.

It is reported that $50,000 has been raised for an observatory at Amherst. The principal instrument is to be a refractor of eighteen inches aperture. The college already possesses a refractor with a 7¼-inch objective and a reflector of 12-inch aperture, and these will be suitably mounted in the new observatory. There are also to be two transit instruments, clocks, a spectroscope, etc. The observatory will be used for purposes of instruction as well as research.

The trustees of the Benjamin Apthorp Gould fund have granted $300 to Goodsell Observatory for the measurement of *Eros* parallax photographs.

Captain COLBY M. CHESTER, U. S. N., has been appointed Superintendent of the Naval Observatory, to succeed Captain C. H. DAVIS, who has been assigned to sea duty.

Dr. E. S. HOLDEN, formerly of the Lick Observatory, has been appointed Librarian at the West Point Military Academy. Dr. HOLDEN is an alumnus of this institution, of the class of 1870.

HERVÉ FAYE, the eminent French astronomer, died at Paris on July 4th. FAYE was born in 1814, and had been prominent in astronomy for sixty years. In 1843 he discovered the comet which bears his name, and which has a period of only seven and a half years. FAYE was connected with the famous Ecole Polytechnique, as student and professor, throughout nearly the whole of his life. He is most widely known through his theory of sun-spots and through his speculations on the origin of the universe. He was a member of the Academie des Sciences, of the Bureau des Longitudes, and of the International Geodetic Association.

In the death of ADELBERT SAFARIK, which occurred at Prague on July 2d, astronomy has lost another long-tried servant. SAFARIK was born in Hungary in 1829, and he received his training at Prague, Berlin, and Göttingen. His astronomical work consists in observations of the planets and the Moon, and especially of variable stars. In spite of the severe illness of the latter part of his life, he is said to have made during this period no less than twenty thousand observations of variable stars. SAFARIK had a broad knowledge of science in general; for a time he was professor of chemistry at Prague. But astronomy was always his favorite, and never were his observations entirely discontinued.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD AT THE LICK OBSERVATORY, ON SEPTEMBER 6, 1902, AT 9 P.M.

President PERRINE presided. A quorum was present. Two new members were elected to the Society, namely:—

THE LIBRARY OF THE U. S. MILITARY ACADEMY	West Point, N. Y.
Professor M. B. SNYDER	Director of the Philadelphia Observatory, Philadelphia, Pa.

The report of the Committee on Membership was then taken up. After full discussion it was moved, seconded, and carried that, in view of the financial questions involved (some mentioned in the Committee's report, and others brought out in discussion), the further consideration of the report be postponed until the regular business meeting in November; that the President be requested to call the meeting at such an hour as to secure a large attendance of the Board with suitable time for deliberation; that the President be requested to invite the attendance of Past-Presidents or others who may be especially interested; and that a copy of the Committee's report be sent in advance to each member of the Board and those specially invited.

The consenting votes of eight Directors having been secured, it was decided to make no award of the Bruce Medal for the year 1903.

Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD AT THE LICK OBSERVATORY, SEPTEMBER 6, 1902, AT 9:30 P.M.

President Perrine presided. The minutes of the last meeting were approved.

The following resolutions were presented, and on motion adopted:—

Whereas, Mr. William M. Pierson has generously offered to bear the deficit in the finances of the Society for the present fiscal year;

Resolved, That the thanks of the Society be tendered to him for this timely aid.

Whereas, Mr. William Alvord has generously contributed the sum of one hundred dollars towards the current expenses of the Society for the present fiscal year;

Resolved, That the thanks of the Society are hereby tendered to him for this opportune gift.

John Dolbeer, a member and former President of this Society, died at his home in San Francisco, on the 17th of August, 1902, at the age of 75 years, 4 months, and 25 days. He was born in Epsom, New Hampshire, in 1827, and came to California fifty-one years ago. During a long and active career in California he was engaged in many enterprises upon a large scale, chiefly appertaining to the lumber industry, and may well be regarded as among the builders of the West. Notwithstanding his active business life, he found time to assist in charitable and scientific undertakings, taking a deep interest, as an amateur, in astronomy.

He was a member of this Society, and had served as one of its directors and also as its President. In the year 1900 he fitted out at his own expense an expedition to observe the eclipse of the Sun at Siloam, Georgia, from which valuable scientific results were obtained. He made generous contributions to astronomical science, and, by his will, a large gift to this Society.

A Committee appointed by President Perrine, consisting of Messrs. Pierson, Molera, and Cushing, presented the following resolutions, which on motion were duly adopted as the expression of the sentiments of this Society:—

Resolved, That by the death of John Dolbeer this community has suffered the loss of a pioneer merchant, in whose career we recognize both the successful business man and the patron of art and science; that this Society has by his death, whether we consider him in the capacity of member, Director, President, or patron, lost one whose sturdy and intelligent support contributed largely to its success.

Resolved, That these resolutions be spread in full on our minutes, and that a copy thereof be sent to the relatives of the deceased as a slight token of our appreciation of our departed friend.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. C. D. PERRINE	*President*
Mr. S. D. TOWNLEY	*First Vice-President*
Miss R. O'HALLORAN	*Second Vice-President*
Mr. CHAS. S. CUSHING	*Third Vice-President*
Mr. R. G. AITKEN Mr. F. R. ZIEL	*Secretaries*
Mr. F. R. ZIEL	*Treasurer*

Board of Directors—Messrs. AITKEN, BABCOCK, CAMPBELL, CUSHING, LEUSCHNER, MOLERA, Miss O'HALLORAN, Messrs. PERRINE, PIERSON, TOWNLEY, ZIEL.

Finance Committee—Messrs. PIERSON, CUSHING, BABCOCK.

Committee on Publication—Messrs. AITKEN, GALLOWAY, SCHLESINGER.

Library Committee—Mr. TOWNLEY, Miss O'HALLORAN, Mr. BRASCH.

Committee on the Comet-Medal—Messrs. CAMPBELL (*ex-officio*), PIERSON, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. RUTHVEN W. PIKE.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. FELIPE VALLE.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.
(February, April, June, August, October, December.)

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OF THE PACIFIC.

VOLUME [illegible]

[illegible]

1902

PUBLICATIONS

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VOL. XIV. SAN FRANCISCO, CALIFORNIA, DECEMBER 1, 1902. No. 87.

THE LONGITUDINAL ABERRATION OF A PARABOLIC MIRROR.

By W. J. HUSSEY.

In the August-September number of *Popular Astronomy*, Professor WADSWORTH has given an investigation of the longitudinal aberration of a parabolic mirror. He calls attention to the difference between the formula for computing this quantity as given by Dr. DRAPER, viz.,

$$a = \frac{y^2}{4f}, \tag{1}$$

and that given by Mr. WASSELL and others, viz.,

$$a = \frac{y^2}{2f} + \frac{y^4}{16f^3}, \tag{2}$$

where a is the longitudinal aberration measured along the axis from the center of curvature for a zone of radius y of a parabolic mirror whose principal focal length is f.

Professor WADSWORTH concludes that the first of these expressions is correct and that the second is wrong. As a matter of fact, when properly interpreted, both formulas are rigorously correct. They are applicable to parabolic mirrors of any aperture and any focal length. They differ because they correspond to different methods of testing. The first formula assumes that the point-source of light and its image as formed by the zone that is being tested are made to coincide; that is, in testing a mirror having the aberrations computed by this formula the source of light and the eye-piece must move together along the axis of the mirror in passing from zone to zone. The second formula assumes that the point-source of light remains fixed at the center of curvature and that its images corresponding to the various zones do not coincide with it, except in the case of the central zone. In testing a mirror having the aberrations computed by the second formula the eye-piece alone is moved along the axis of the mirror in passing from zone to zone.

The above formulas may be derived easily, without recourse to calculus. Let Figure 1 represent a section of a paraboloid of revolution by a plane containing the axis. Let V be the vertex and F the focus of the parabolic section, and D the center of curvature of the parabola at the vertex. Then $VF = FD = f$. Taking the origin at the vertex and the axis of the parabola as the axis of abscissas, the equation of the parabola is

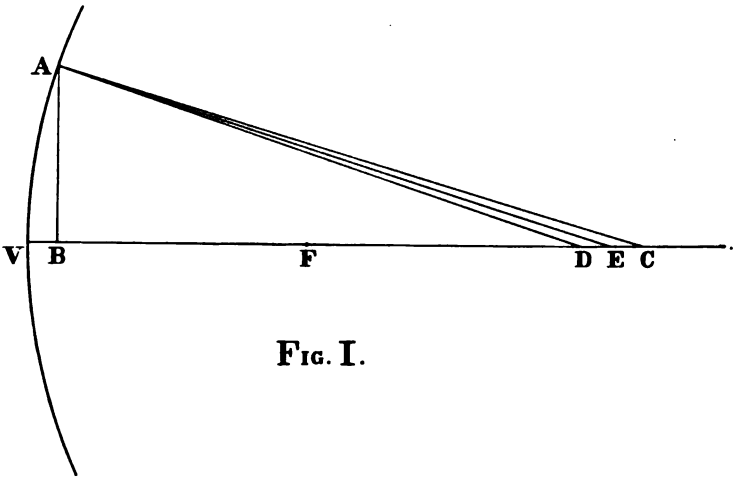

FIG. I.

$$y^2 = 4fx \tag{3}$$

Let A be a point in the parabola at a distance BA from the axis, and AE the normal to the parabola at A. Let the coordinates of A be x' and y'.

CASE I. *Point-source of light and its image coincident.*—Let the point-source of light and its image be placed at E. A ray EA meets the surface of the mirror normally at A and is reflected along the path AE. Moreover, all rays which emanate from E and make an angle equal to VEA with the axis are also reflected in paths which pass through E. E is therefore the image of E as formed by these rays, and the distance DE is the longitudinal aberration of the infinitely narrow zone A of radius $AB = y'$. The subnormal BE of the parabola is constant and equal to $2f$. VD is also equal to $2f$. Consequently, $DE = VB = x' = \frac{y'^2}{4f}$. Or, dropping the accents and writing a in place of DE, we have the required formula as follows:—

$$a = \frac{y^2}{4f}. \tag{1}$$

CASE II. *Point-source of light fixed at the center of curvature.*—Let the point-source of light be placed at the center of curvature D. A ray DA meets the surface of the mirror at A and is reflected along the path AC, making the angles DAE and EAC equal, these being respectively the angles of incidence and reflection. All rays which emanate from D and make an angle equal to VDA with the axis lie in the surface of a right cone which intersects the paraboloid in a circle of radius $AB = y'$, and they are reflected in rays which all lie in the surface of another right cone whose vertex is at C and whose semi-vertical angle is VCA. C is therefore the image of D formed by the rays which lie in the surfaces of the cones mentioned, and DC is the longitudinal aberration of the infinitely narrow zone A of radius $AB = y'$.

The coordinates of D are $2f$ and 0; those of E are $2f + x'$ and 0; and those of C are $2f + a$ and 0. Having the coordinates of A, D, E, and C, we may write the equations of the lines AD, AE, and AC. They are respectively as follows:—

$$y = \frac{y'}{x' - 2f}x - \frac{x'y'}{x' - 2f} + y', \tag{4}$$

$$y = -\frac{y'}{2f}x + \frac{x'y'}{2f} + y'. \tag{5}$$

$$y = \frac{y'}{x' - 2f - a}x - \frac{x'y'}{x' - 2f - a} + y'. \tag{6}$$

In these equations the coefficients of x are the tangents of the angles which these lines make with the axis of abscissas. Now, if m and m' are the tangents of the angles which any two lines make with the axis of abscissas, the angle θ included between these lines is given by the expression

$$\tan \theta = \frac{m - m'}{1 + m m'}. \tag{7}$$

If we substitute in this the values of m and m' from the equations of DA and AE, and also those of AE and CA, we shall obtain respectively the tangents of the angles DAE and EAC. These angles are necessarily equal. We may therefore equate the values of their tangents. Doing this and solving the resulting expression for a, we obtain the following rigorous expression for the longitudinal aberration of a parabolic mirror:—

$$a = 2x' + \frac{x'^2}{f}, \tag{8}$$

or, substituting $\frac{y'^2}{4f}$ for x' and dropping the accents,

$$a = \frac{y^2}{2f} + \frac{y^4}{16f^3}. \tag{2}$$

A more general formula for the longitudinal aberration, of which the equation just given is a special case, may be readily derived. It is here considered as

CASE III. *Point-source of light situated upon the axis at a distance d from the vertex.*—The coordinates of the source of light are now d and 0. Let those of its image corresponding to the zone of radius y' be denoted by $h + a$ and 0, where h is the distance from the vertex at which the image is formed by that portion of the mirror which is situated at the vertex, and where a is the aberration required. In this case the aberration is reckoned from a point in the axis at a distance h from the vertex.

The argument and method here are the same as in the preceding case. The equations of the incident ray, the normal, and the reflected ray are respectively as follows:—

$$y = \frac{y'}{x' - d}\,x - \frac{x'y'}{x' - d} + y'. \tag{9}$$

$$y = -\frac{y'}{2f}\,x + \frac{x'y'}{2f} + y', \tag{10}$$

$$y = \frac{y'}{x' - h - a}\,x - \frac{x'y'}{x' - h - a} + y'. \tag{11}$$

The expressions for the tangents of the angles included between the first and second, and between the second and third of these lines are formed and equated. When the resulting expression is simplified and x' eliminated through the use of the equation $y'^2 = 4fx'$, and the accents dropped, it reduces to

$$a = \frac{y^2}{2(d-f)} + \frac{y^4}{16f^2(d-f)} + \frac{f(d+h) - dh}{d-f}. \qquad (12)$$

Now, from the manner of selecting the distance h, it will be seen that a and y vanish simultaneously. Consequently the constant term of the last equation is equal to zero. From this condition we get the relation between h and d, as follows:—

$$h = \frac{fd}{d-f} = f + \frac{f^2}{d-f}. \qquad (13)$$

At the same time the preceding equation reduces to

$$a = \frac{y^2}{2(d-f)} + \frac{y^4}{16f^2(d-f)}, \qquad (14)$$

which is the complete formula for the longitudinal aberration of an infinitely narrow zone of a parabolic mirror, the source of light being situated anywhere upon the axis.

If the source of light is placed at the center of curvature, $d = 2f$, and $h = 2f$, and the last equation reduces to

$$a = \frac{y^2}{2f} + \frac{y^4}{16f^3}, \qquad (2)$$

as given in Case II.

If the source of light is placed at an infinite distance,—that is, if the mirror is directed to a star,—d becomes infinite and at the same time $h = f$, and $a = 0$. Or, in other words, rays parallel to the axis are brought to a focus from all parts of the mirror, free from aberration, at the principal focus of the mirror.

In the preceding paragraphs it has been assumed that the rays of light are reflected from an infinitely narrow zone of the mirror, the zone being circular and having its center in the axis of the paraboloid. The zones actually used in testing a mirror necessarily have a finite width. In consequence of this the rays of light which are reflected from the surface of such a zone as is used in practice do not all intersect in the same point of the axis. This will be evident from the following concrete example, which we shall regard as

CASE IV. *Point-source of light fixed at the center of curvature D and zone of finite width,* as indicated by *AB, A'B'* of Figure 2.

According to these hypotheses the rays of light which are reflected from *A* and *B* respectively intersect the axis in points *C* and *G,* the aberrations *DC* and *DG* being those given by equation (2). Rays reflected from points between *A* and *B* meet the axis in points between *C* and *G.* The extreme rays *AC* and *BG* intersect in *H,* but since no other rays from the zone under consideration intersect in *H, H* is not an image of *D* as formed by rays from any portion of this zone. On the contrary, the rays which are reflected from that part of the surface from *A* to *B* inclusive, when taken in all possible combinations of two at a time, have points of intersection which completely fill the region *HCG.* The symmetrical portion of the zone *A'B'* likewise furnishes rays which intersect the axis in points between *C* and *G,* and which when taken two at a time have points of intersection which completely fill the region *KCG,* symmetrical with *HCG.*

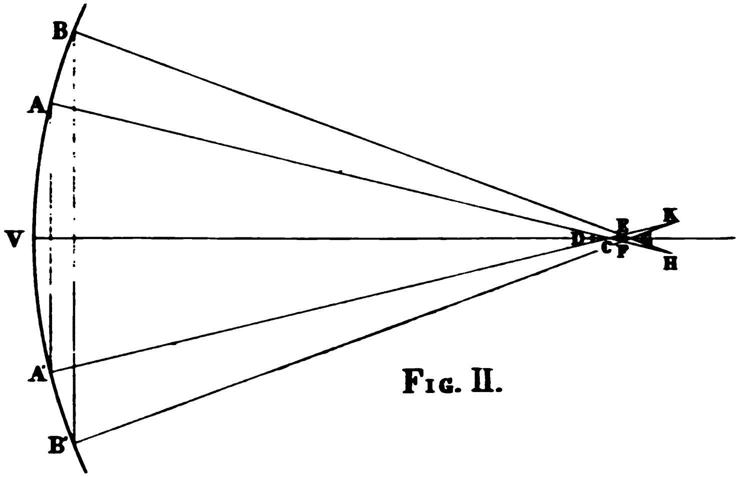

FIG. II.

The rays from *A'* and *B,* and those from *A* and *B'* intersect respectively in the points *E* and *F.* Let the line joining *E* and *F* intersect the axis in *L*.* Then it is evident that *VL* is the distance from the vertex at which the cross-section of the rays reflected from the entire circular zone *AB, A'B'* has its minimum diameter. When the zone is of finite width, as here assumed, there is no point in which all the rays reflected from the zone intersect, and therefore there is no single all-embracing focal point. But in passing the circle of which *EF* is the diameter the rays are crowded together more closely than elsewhere, so that in this circle we have the nearest approach to the formation of an image of the point *D* by all the rays which are reflected from the zone of finite width *AB, A'B'*. This circle is called *the circle of least confusion*. We will next determine its position and radius.

Let x', y' be the coordinates of *A* and x'', y'' those of *B*. Then the equations of *A'C* and *BG* are respectively as follows:—

$$y = -\frac{y'}{x' - 2f - a'}\,x + \frac{x'\,y'}{x' - 2f - a'} - y', \qquad (15)$$

$$y = +\frac{y''}{x'' - 2f - a''}\,x - \frac{x''\,y''}{x'' - 2f - a''} + y'', \qquad (16)$$

where, according to equation (2),

$$a' = \frac{y'^2}{2f} + \frac{y'^4}{16f^3},$$

and

$$a'' = \frac{y''^2}{2f} + \frac{y''^4}{16f^3}.$$

E is the point of intersection of these lines. Its abscissa is the distance of the circle of least confusion from the vertex of the paraboloid, and its ordinate is the radius of this circle. Hence, if we solve equations (15) and (16), to get the coordinates of their point of intersection, we shall have the quantities required. In the unreduced form the resulting expressions are somewhat complicated. If, after forming them, we put

$$y'' + y' = 2\,z,$$

$$y'' - y' = 2\,w,$$

---

* The letter *L* is omitted from the diagram, the space available not being sufficient to give it clearly. Its location is evident from the description of the diagram.

we find that they may be reduced to the following forms:—

$$VL = 2f + \frac{z^2 + 3w^2}{2f} + \frac{z^4 + 6z^2w^2 + 9w^4}{16f^3} + \frac{w^2e}{fk} + \frac{w^2g}{4f^3k}, \quad (17)$$

and,

$$LE = \frac{4w(z^2 - w^2)(4f^2 + z^2 + w^2)}{k}, \quad (18)$$

where, for brevity, we have written

$$k = 32f^4 + 4f^2(z^2 - w^2) + (z^2 - w^2)(z^2 + 3w^2),$$

$$e = -5z^4 - 2z^2w^2 + 7w^4,$$

$$g = -3z^6 - 3z^4w^2 - z^2w^4 + 7w^6.$$

If the aberration is measured from the center of curvature, we have

$$a = VL - VD = VL - 2f$$

as the value of the longitudinal aberration of the circle of least confusion. This is given directly by transposing $2f$ from the second to the first member of equation (17). The last two terms of equation (17) are very small for such mirrors as are used for reflecting telescopes and may be omitted without material error. Neglecting them, we have

$$a = \frac{z^2 + 3w^2}{2f} + \frac{z^4 + 6z^2w^2 + 9w^4}{16f^3}, \quad (19)$$

which is a very approximate expression for the longitudinal aberration of a zone of width $2w$ and mean radius z of a parabolic mirror whose principal focal length is f.

Equation (2) is a special case of the one last given. When an infinitely narrow zone is taken, w may be put equal to zero; the omitted terms vanish, and equation (19) reduces to the form of equation (2). Further, the diameter of the circle of least confusion becomes evanescent along with w, as will be seen from a consideration of equation (18).

CASE V. *Point-source of light situated upon the axis at a distance d from the vertex, the zone being of finite width.*

Let the aberration be measured from a point on the axis at a distance h from the vertex. Then the equations of the reflected rays $A'C$ and BG are like (15) and (16), except that $2f$ is replaced by h and the aberrations a' and a'' now have the complete form of equation (12). The method here is precisely the same as for the preceding case. The results are

$$VL = \frac{fd}{d-f} + \frac{z^2 + 3\,w^2}{2\,(d-f)} + \frac{z^4 + 18\,z^2\,w^2 - 3\,w^4}{16\,f^2\,(d-f)}$$

$$+ \frac{3\,(-\,z^2\,w^2 + w^4)}{2\,d\,f\,(d-f)}, \qquad (20)$$

and

$$LE = \frac{4\,w\,(z^2 - w^2)\,(4f^2 + z^2 + w^2)}{t}, \qquad (21)$$

where in the value of VL we have omitted the terms which are insensible in all practical cases. The several omitted terms are those corresponding to the last two terms of equation (17) and like them contain the factor w^2 in their numerators, while their denominators are at lowest of the order f^4.

In the denominator of (21), for brevity we have put

$$t = 16\,f^3\,d + 4\,f\,(z^2 - w^2)\,(3\,f - d) + (z^2 - w^2)\,(z^2 + 3\,w^2).$$

From equation (21) it will be seen that the diameter of the circle of least confusion becomes evanescent along with w.

If the aberration is measured from a point upon the axis at a distance h from the vertex of the paraboloid, we shall have for its value

$$a = V\,L - h. \qquad (22)$$

VL being given, in general, by equation (20) and h by (13). When the aberration is measured from the center of curvature the last equation becomes

$$a = V\,L - 2\,f. \qquad (23)$$

Equations (1) and (2) may both be obtained from (23) by giving to w, z, and d in VL values corresponding to the conditions imposed in the derivation of (1) and (2). In each case the zone then becomes infinitesimal in width. Hence $w = 0$, and we may put $z = y$. When the light is placed at the foot of the normal, *i. e.* at E in Figure 1,

$$d = x + 2\,f,$$

and in accordance with these circumstances equations (20) and (23) give

$$a = \frac{y^2}{4f}.$$

When the light is fixed at the center of curvature, *i. e.* at D in Fig. 1,

$$d = 2f,$$

and the same equations give

$$a = \frac{y^2}{2f} + \frac{y^4}{16f^3}.$$

MT. HAMILTON, CALIFORNIA, October 22, 1902.

OBSERVATIONS OF THE ECLIPSED MOON, OCTOBER 16, 1902.

BY ROSE O'HALLORAN.

The atmosphere here was very favorable to observation during the total phase of the recent lunar eclipse, which occurred on October 16th, in accordance with astronomical forecast. Some minutes before its symmetry was noticeably impaired, the east limb of the Moon was dimmed by the terrestrial shadow, which within half an hour had successively submerged *Grimaldi, Aristarchus, Kepler, Gassendi,* and *Tycho.* Cirrus clouds flitted by during the half-moon phase, and the crescent was formed before the shadowed surface became discernible. A narrow semicircular strip round the limb was first suffused with the glow of refracted sunlight, wreathing the dark terrestrial hemisphere, and large tracts adjacent to *Tycho,* where lunar seas are scarce, were soon included in this interesting illumination. Though familiar with descriptions of our satellite when eclipsed in recent and former years, the color was more vivid than I anticipated, and, telescopically, it was distinctly pink.

At 9:16 P. M. the shadow was over *Mare Crisium* and the crater *Petavius,* but for some minutes after totality the foreshortened limb west of these features shone with a dull white light. This was succeeded by a luminous pink hue that could not be classed as either coppery or chocolate-colored. Probably it was caused by a mingling of white light with unusually red rays from the atmospheric aureole. At first the central portion of the disk seemed to be shrouded from this beacon of totality, but before long the seas were discernible, even without magnifying power. If an observer were uninfluenced by known facts, the telescopic view was that of a translucent sphere whose central fires gleamed out more or less through the surface, according to the thickness of the crust. The white streaks so conspicuous at full moon were discernible and conveyed less impression of translucency than the other tracts, which were salmon-colored. The seas were in contrast to both, resembling a dull gray substance on which red light is cast. As the eclipsed orb advanced more centrally, its pink color declined and the time-honored coppery light held full sway for about half an hour. At this stage, but for the familiar outlines of the seas, the Moon seemed like a dusky intruder among the small stars of *Pisces* that shone so brightly through the shadow depths. In color it bore little resemblance to the ashen surface visible when the Moon is young. Before the end of totality the brighter hues reappeared, the pink glow on the east limb as it neared sunlight giving place again to a dull white that lingered until direct rays ended the total phase.

Though no mystery attaches to the encounter between the Earth's shadow and satellite, and its scientific value is limited, still as seen here to full advantage it was an impressive fulfillment of astronomical prediction and theory not soon to be forgotten.

San Francisco, October 21, 1902.

PLANETARY PHENOMENA FOR JANUARY AND FEBRUARY, 1903.

By Malcolm McNeill.

Phases of the Moon, P. S. T.

First Quarter,	. . . Jan. 6,	1h	56m	P. M.
Full Moon,	. . . Jan. 13,	6	17	A. M.
Last Quarter,	. . . Jan. 20,	3	49	
New Moon,	. . . Jan. 28,	8	39	
First Quarter,	. . . Feb. 5,	2	12	
Full Moon,	. . . Feb. 11,	4	58	P. M.
Last Quarter,	. . . Feb. 18,	10	23	
New Moon,	. . . Feb. 27,	2	20	A. M.

The Earth is at perihelion at 5 P. M., January 3d, Pacific time.

Mercury is an evening star throughout January, passes inferior conjunction with the Sun on the morning of February 2d, and becomes a morning star. It reaches greatest east elongation on January 17th, being at that time not quite 19° east of the Sun. For a few days near that date it sets at about an hour and a half after sunset, and may be seen easily in the twilight on a clear evening, and for perhaps a fortnight before time of greatest elongation it can be seen under good conditions of weather. The planet's distance from the Sun diminishes rapidly after January 17th until it reaches conjunction. It then moves rapidly away from the Sun, and on February 27th it attains greatest west elongation, not quite 27°. It may for a few days be seen as a morning star, but the conditions for visibility are not nearly as good as during January, the maximum interval between the rising of the Sun and of the planet being only a few minutes more than one hour. The greater southern declination of the planet during February more than counterbalances the effect of the greater distance from the Sun at that time. The difference in distance is due to the fact that the planet is in perihelion only a week later than the greatest east elongation of January, and it is in aphelion only nine days after the west elongation in February.

Mercury while still moving eastward passes 1° 47′ south of *Saturn* on January 5th. Both planets are then almost too near the Sun to be seen easily, unless weather conditions are very favorable. After both planets become morning stars there is another conjunction on February 13th. There is also a conjunction between *Mercury* and *Venus* on January 25th, after *Mercury* has begun to approach the Sun, *Mercury* passing 3° 20′ north of *Venus*.

Venus is now an evening star, having passed inferior conjunction with the Sun late in November. On January 1st it remains above the horizon only half an hour after sunset; but this interval increases to a little more than an hour by the end of the month, and at the end of February it is nearly two hours. On account of its greater brightness *Venus* can be seen when at a much smaller distance from the Sun than can *Mercury*, but it will not be an easy object during the early days of January. On the afternoon of January 9th it is in conjunction with *Saturn,* passing a little less than 1° south of the latter. The relative motions of *Venus, Mercury,* and *Saturn* during the early days of January are very interesting, but the planets are too near the Sun for easy observation. On the afternoon of January 30th *Venus* is also in conjunction with Jupiter, passing to the south, and still nearer than it did to *Saturn,*—so near that both planets can be seen together in the field of view of a small telescope.

Mars rises a little before midnight on January 1st, at about 10^h 30^m on February 1st, and before nine on February 28th. It moves 10° slowly eastward and southward among the stars in the western part of the constellation *Virgo* until February 15th. On that date it becomes stationary, and then begins to retrograde. Its actual distance from the Earth in miles diminishes from one hundred and seventeen millions, on January 1st, to ninety millions, on February 1st, and to sixty-nine millons, on March 1st, and there will be a corresponding increase in brightness, so that toward the end of the period the planet will become quite conspicuous and the principal feature of the eastern sky late at night.

Jupiter is an evening star in January, and remains so until February 19th, when it comes to conjunction with the Sun and becomes a morning star. It is far enough away from the Sun throughout January to be seen easily in the evening, setting about three hours after sunset on January 1st. The interval diminishes about one half during the month, and after the first few days of February the distance between planet and Sun becomes too small for visibility of the planet after sunset.

Saturn is also an evening star on January 1st, but is much nearer the Sun than is *Jupiter.* It then sets less than an hour and a half after sunset, and, being much less bright than *Jupiter,* it will not be a conspicuous object. It passes conjunction with the Sun on January 20th, and becomes a morning star. By the end of February it rises about an hour and a half before sunrise.

Uranus is a morning star, not far enough away from the Sun for naked-eye view until late in February.

Neptune is in the western sky in the evening. It is in *Gemini,* but too faint to be seen without a telescope.

OBSERVATIONS OF THE TOTAL ECLIPSE OF THE MOON, OCTOBER 16, 1902.

The total lunar eclipse of October 16, 1902, was observed at the Students' Observatory of the University of California, by the students in Practical Astronomy. Some of these have had but little experience in observational work, and their results have consequently been given smaller weights. The weights have been assigned in a somewhat arbitrary manner, from consideration of experience of the observers, instruments used, etc. The atmospheric conditions were good. The observations and results are contained in the following tabulation.

Sidney D. Townley.

TOTAL ECLIPSE OF MOON, 1902, OCTOBER 16.

Phase.	P. S. T.	O − C.	p.	Instrument.	Observer.	Remarks.
	8^h					
Enters shadow	16.8^m	-0.5^m	2	Finder of 6″	J. D. MADDRILL	Definition poor.
	17.7	+0.4	2	Surveyor's Transit	GEO. DICKIE	
	16.8	−0.5	2	Alt-azimuth	M. VAN WORMER	
	18.0	+0.7	2	5″ Refractor	Mrs. E. HUBBARD	
	18.0	+0.7	1	Eye	Mrs. J. KOETHEN	Time probably taken from Mrs. HUBBARD'S observations.
	15.5	−1.8	0	Field-glasses	Miss E HADLEY	Watch comparison uncertain.
	16.8	−0.5	3	6″-Refractor	A. F. GILLIHAN	
Weighted mean		- 0.05				
	9^h					
Totality begins	20.5^m	+1.5	2	Finder of 6″	J. D. MADDRILL	
	19.8	+0.8	2	Surveyor's Transit	GEO. DICKIE	
	19.9	+0.9	2	Alt-azimuth	M. VAN WORMER	
	20.5	+1.5	1	Opera-glasses	Mrs. E. HUBBARD	
	20.5	+1.5	1	Eye	Mrs. J. KOETHEN	
	20.8	+1.8	2	3″-Refractor	Miss G. TODD	
	22.1	+3.1	0	Field-glasses	Miss E. HADLEY	Watch comparison uncertain.
	19.3	+0.3	3	6″-Refractor	A. F. GILLIHAN	
	21.0	+2.0	2	Finder of 3″	S. D. TOWNLEY	
	20.3	+1.3	1	Eye	CHAS. PETIT	
	20.6	+1.6	1	Eye	E. E. EVERETT	
Weighted mean		+1.22				
	10^h					
Totality ends	48.4^m	+0.5	2	Finder of 6″	J. D. MADDRILL	
	48.1	+0.2	3	6″-Refractor	A. F. GILLIHAN	
	48.7	+0.8	2	Finder of 5″	S. D. TOWNLEY	Uncertain, — for 2 min. preceding light was coming fast,—totality certainly over by this time.
Weighted mean		+0.46				
	11^h					
Leaves shadow	49.4^m	−0.3	2	Finder of 6″	J. D. MADDRILL	
	49.3	−0.4	3	6″-Refractor	A. F. GILLIHAN	
	49.9	+0.2	2	Finder of 3″	S. D. TOWNLEY	
Weighted mean		−0.20				

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

COMET *b* 1902 (PERRINE).

This comet is proving to be of more than usual interest, by reason of its rapidity of motion, its brightness, the long duration of its apparition period, and its close approach to the planet *Mercury*.

As seen from the Earth, at the time of discovery, the comet was moving slowly northward and westward, but the first calculation of its orbit showed that its motion would rapidly increase and that it would pass within about thirty-five millions of miles of the Earth on about the 8th of October. As it was also coming toward the Sun, its brightness would increase rapidly, reaching its maximum at the time of nearest approach to the Earth, provided, that is, that it was shining by reflected sunlight.

Assuming that the brightness at discovery was that of a 9th-magnitude star, its theoretical brightness on October 8th should have been about that of a 5½-magnitude star, and should then have diminished slowly.

Observations made here show that the comet somewhat exceeded its theoretical brightness, being easily visible to the naked eye as early as September 24th, and that its light did not diminish as fast in the latter part of October as the theory of reflected light required. This will appear from a few estimates of its brightness taken from my observing notes.

Sept. 24.	Comet as bright as 6.1 magnitude star near south following. Easily visible to naked eye.
Oct. 3.	Comet fully as bright as 5th magnitude star.
Oct. 14.	Comet passed between 109 and 110 *Herculis*. Very little fainter than these stars. Certainly not a half

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* Lick Astronomical Department of the University of California.

magnitude. [The Harvard Photometry gives the magnitudes of 109 and 110 *Herculis* as 3.9 and 4.2, respectively.]

Oct. 21. Comet near a star 5.9 magnitude, and is at least a magnitude brighter.

Oct. 27. Comet fully as bright as 5th magnitude.

Nov. 4. Comet still easily seen with naked eye, though very low in the sky.

While there is thus evidence that the comet's light is not all reflected light, there have been so far no erratic variations in its brightness such as sometimes characterize a comet on its approach to the Sun.

The comet's approach to the Earth is closer than the average, but not sufficiently close to be worthy of special remark, but the close approach that Mr. F. E. SEAGRAVE has found it will make to the planet *Mercury* on November 29-30th is most unusual and of great interest. According to the best published ephemeris of the comet, the distance separating it from the planet will not greatly exceed two millions of miles at the time of closest approach.

Professor PICKERING points out that careful observations made of the comet after November 29th will afford the means of determining the effect of the disturbance of its motion by *Mercury* with such accuracy that a good value of the mass of planet may be derived. Unfortunately the comet passes the Sun on November 26th, and at the time of nearest approach to *Mercury* it will still be so close to the Sun that for a number of days accurate observations will be impossible. Observers in the southern hemisphere, however, will have a good opportunity to secure observations later on—for not the least remarkable feature of this comet is the great length of its apparent path through the sky. Discovered in 3^h 18^m Right Ascension, and 34° 39′ North Declination, it moved north and west till it reached its maximum North Declination of 57° on September 30th. At that time its Right Ascension was 23^h 34^m. Still continuing its westward motion, it turned also toward the south, and on November 4th was observed here in 17^h 9^m Right Ascension and —8° 10′ Declination. According to the ephemeris given by STRÖMGREN in *A. N.* 3821, the southwesterly motion continues until January 19, 1903, by which time the comet's position will be 11^h 18^m Right Ascension and —46° 27′ Declination. It then turns to the northwest, and by March 3, 1903, the last date of the ephemeris, it has reached 6^h 35^m Right Ascension and —11° Declination. At this time its theoretical brightness is still 0.6 that at discovery, and therefore it should be easy to observe until the end of March at least.

In view of its close approach to *Mercury*, and of the long duration of visibility of the comet, it seemed desirable to have a set of elements that would represent its motion with more accuracy than could be expected of the preliminary elements.

I therefore computed a set of parabolic elements based on the discovery position and my own observations made on October 2d and November 1st.

The elements had been derived and an ephemeris planned when the *Astronomische Nachrichten* containing STRÖMGREN'S ephemeris reached me. For comparison I give the two sets of elements here:—

	STRÖMGREN.		AITKEN.	
$T =$	1902, Nov. 23.88925 M. T. Berlin.		Nov. 23.85514 Greenwich M. T.	
$\omega =$	152° 57′ 28″.2	1902.0	152° 57′ 50″.3	1902.0
$\Omega =$	49 21 7 .5		49 21 17 .3	
$i =$	156 21 9 .8		156 21 5 .1	
$\log q =$	9.603246		9.603212	

Reduced to Greenwich mean time, STRÖMGREN'S T becomes Nov. 23.85204. Evidently the two sets of elements are so nearly identical that it would be waste of time to compute an ephemeris from mine.

It is hoped that in the next number of these *Publications* we may be able to reproduce some of the fine photographs of the comet that have been secured here by Mr. R. H. CURTISS.

November 12, 1902. R. G. AITKEN.

OBSERVATIONS OF δ *EQUULEI*.

On account of the shortness of its periodic time and by reason of its forming a determinate connecting link between the visual and spectroscopic binaries, δ *Equulei* may be regarded as the most interesting of all the double stars. The early determinations of its orbit gave about 11.45 years as the time of revolution, but the observations made within the past three years show that this value is erroneous, and they further make it evident that the true period is not far from 5.7 years. This is shorter by nearly half than that of any other visual double star.

The spectrum of δ *Equulei* is not constantly the same. There are relative shiftings of the lines which make them appear broader at some epochs than at others. This is due to the relative motions of the two stars. The variations in the spectrum, so far as they have been observed, are perfectly in accord with the short period of 5.7 years, but they do not agree at all with the longer one.

The first orbits obtained for this binary, those having periods of about 11.45 years, are nearly circular. In deriving them the computers assumed that the companion receded to about equal apparent distances from the principal star on either side of it, and that the motion was in a plane having, as is true, a very high inclination. The apparent ellipse which they obtained was very elongated, and the principal star was near its center. This corresponds to a nearly circular orbit, and to changes in the apparent distance which should take place very nearly in the manner of simple harmonic motion. The observations secured since the summer of 1899 show conclusively that the apparent distance does not change in this manner. Between October, 1899, and July, 1900, the distance decreased far more rapidly than was expected. On the first of these dates it was about one third of a second; on the last Professor AITKEN found it too small for exact measurement with the great refractor. It was then much less than a tenth of a second.

During the summer of 1901 the distance increased to about 0".15 and then decreased again. By the middle of December it had become so small that the star appeared nearly or quite round even under the most favorable conditions. These variations of distance, with a maximum of about 0".15 on one side of the principal star and of about 0".40 on the other, are fatal to the old hypothesis that the period of this pair is about 11.45 years, and they are entirely in accord with the theory that the period is about 5.7 years.

My measures of this pair to the middle of August, 1901, are given in Volume V of the *Publications of the Lick Observatory*. Those secured subsequently are given below. Professor Aitken has also measured this star on some of the same nights, and when this was done we have taken the precautions mentioned in his accompanying article to render our results wholly independent. All the measures have been made with the 36-inch refractor. The powers used are indicated in the last column. The eye-piece giving a power of 2400 is the very excellent one that we constantly use on the 12-inch telescope, where it has a power of somewhat more than 600. A new adapter was made to enable us to use it in measuring this star with the large telescope last year, when the distance was becoming so small.

Measures.

1901.715	206°.1	0″.09	1900
.742	205 .7	0 .08	1500
.756	208 .0	0 .07	1900
.778	206 .0	<0 .10	1500
.781	206 .0	0 .07	2400
.793	198 .2	0 .05	2400
.833	194 .1	0 .05 est.	2400
.853	194 .7	0 .05 est.	2400
.890	With power 1000 the image is apparently round. With power 2400 there appears to be a very slight elongation in the direction 200°, but the distance appears to be not so great as 0″.05. Seeing good.		
.968	With power 2400 elongation uncertain. Distance regarded under 0″.05, and certainly too small to be measureable. Turned at once to κ *Pegasi*. Its distance was less than 0.10, yet its elongation was easily seen.		
1902.389	25°.8	<0″.10	2400
.463	38 .1	0 .07 est.	2400
.545	46 .9	0 .08	2400
.597	42 .8	0 .09	1500
.638	36 .2	0 .12	2400
.695	43 .1	0 .12	1500
.723	41 .1	0 .13	2400
.753	35 .9	0 .16	2400
.788	39 .1	0 .16	2400
.827	38 .2	0 .15	1500

Mt. Hamilton, Nov. 14, 1902. W. J. Hussey.

FURTHER MEASURES OF δ *EQUULEI*, OΣ 535.

In a note on this interesting binary star published in number 79 of these *Publications*, I gave two measures made in May, 1901, which showed that the distance between its two components was increasing, after the close approach observed in the autumn months of 1900. The pair was closely followed by Professor HUSSEY and myself until December 19th of last year, and our observations left no doubt of the fact that the distance between the components reached a maximum value of about 0″.15 in June, 1901, and then slowly diminished until in November and December it was so small that the combined disk gave only the slightest indication of elongation when examined with the highest-power eye-pieces of the 36-inch telescope.

My first opportunity to observe the star this year under fairly good conditions came on morning of June 8th. At that time it was certain that the image was elongated, though the distance was too small to make the measure of the direction of elongation very accurate. Since that date Professor HUSSEY and I have measured the pair on a number of nights, and have found the distance to be increasing until it has become a fairly easy pair to observe with the 36-inch on good nights. At the time of my last observation the two components were distinctly separated at moments, and the distance between their centers was certainly as great as 0″.15.

My observations to October 31, 1901, have been published in Lick Observatory Bulletin No. 11. Those made since then are as follows:—

Date.	Position-Angle.	Distance.	Eye-piece.	Seeing.
1901.833	Elongation too slight for good measures.	....	2400	3
.852	194.°5	0″.05 ±	2400	4
.967	No certain elongation.	< 0″.05	2400	4
1902.433	70°.0 ±	< 0 .10	1900, 2400	3
.597	35 .7	0 .10	2400	3
.638	38 .3	0 .12	2400	4
.684	33 .6	0 .14	1900	3
.753	34 .2	0 .13	2400	3
.788	36 .6	0 .14	2400	3
.794	34 .9	0 .17	1500	3

On the three nights in 1901, Professor HUSSEY was with me. We examined γ *Equulei* immediately after making our measures on the second night. Its image was perfectly round at the best moments, and when distorted by atmospheric disturbances, the slight apparent elongation was nearly perpendicular to the position-angle measured for δ *Equulei.* On the third night, after examining δ *Equulei,* we turned at once to κ *Pegasi.* The elongation in this pair was unmistakable, though, from measures made here and elsewhere, it is certain that the distance was not over 0".08. On these nights as on the others when we examined this star together, we used every precaution to make our work independent. When measures were made, one would make the settings, the other read the circle and record, so that the observer could know nothing about his measures till they were completed and on record. On several nights a third person read the circle and recorded for both observers.

From the observations made here since the summer of 1899, it is safe to conclude that the revolution period of 5.7 years which Professor HUSSEY found from his study of the orbit, is very close to the truth. It also appears that the plane of the orbit is not exactly in the line of sight, but that the apparent motion is in a very narrow ellipse. The inclination of the orbit plane probably is as great as 80°, but to determine this and the remaining elements of the orbit with precision will require careful and continuous measures during the next three years.

R. G. AITKEN.

November 13, 1902.

THE *LEONIDS* OF 1902.

Watch for *Leonids* was kept by the writer during the nights of November 14th and 15th, a total number of nineteen being seen on the first night and twenty-nine on the second. Except for the moonlight, the general conditions were very favorable. A few light clouds came over at times, but they were not enough to affect seriously the count of meteors. The observer's attention was fixed on the Sickle, and all meteors which certainly emanated from the radiant were counted as *Leonids,* doubtful cases being classed with those which were surely not *Leonids.* In brightness, the *Leonids* observed ranged from one which was equal to *Sirius* to some of the fifth magnitude. Six or eight were as bright as *Regulus*. Of those which were seen at a distance of say thirty degrees or more from the radiant, nearly all must have been at least as bright as the third magnitude.

Following are the data of the observations:—

Astronomical Date.	Pacific Standard Time.			*Leonids.*	Other Meteors.	Remarks.
1902.						
Nov. 14.	$13^h 01^m$	to	$14^h 00^m$	2	5	
	14 00		15 00	5	3	Clouded over at $15^h 00^m$
	15 33		16 00	3	4	Perfectly clear.
	16 00		16 30	3	1	
	16 30		17 00	2	2	Sky 7/10 cloudy at $16^h 30^m$ Clear again in five minutes.
	17 00		17 30	4	3	
	Total in		$3^h 56^m$	19	18	
Nov. 15.	13 09		13 30	1	0	Light clouds at times during the night, but they did not interfere.
	13 30		14 00	1	0	
	14 00		14 30	0	2	
	14 30		15 00	3	0	
	15 00		15 30	0	0	
	15 30		16 00	6	1	
	16 00		16 30	7	0	
	16 30		17 00	8	0	
	17 00		17 30	3	0	Clouded over at $17^h 30^m$
	Total in		$4^h 21^m$	29	3	

The relatively large number of other meteors on the first night was not due to the inclusion of doubtful cases. The observing conditions were the same on both nights. From the roof of the main building there was an unobstructed view of the sky from the zenith to the eastern horizon. As much of the space around the radiant was covered as the eye can take in at one time.

JOEL STEBBINS.

AN UNUSUAL TRIPLE STAR.

In the latter part of September I discovered a triple star which is unlike any other that I have seen. The differences in the magnitudes of the three stars are not very great and the configuration is that of an almost perfect equilateral triangle.

The means of the measures of distance on two nights with the 36-inch telescope are as follows:—

A B	1″.55.
B C	1″.47.
C A	1″.61.

Such triples, had we more of them, affording a gradation of distances from those which are very small to those which amount to several seconds of arc, would enable investigations relating to the personal errors in the measurement of position-angle to be undertaken with a promise of reaching more conclusive results than have characterized such investigations in the past.

This star is D. M. + 49° 95. Its position, derived from the Bonn A. G. Catalogue, where its magnitude is given as 8.9, is as follows:—

$$\left.\begin{array}{l} \text{R. A.} = 0^h\ 22^m\ 21^s.14. \\ \text{Decl.} = +49^\circ\ 28'\ 10''.9. \end{array}\right\}\ 1900.0.$$

W. J. Hussey.

Eclipse of the First Moon of *Jupiter*.

[Dr. E. S. Holden has kindly sent us the following letter received by him, as it will be of general interest.—*Publication Committee.*]

St. Louis, Mo., Oct. 21, 1902.

Dear Sir:—The transits of the moons and their shadows across the disk of the planet *Jupiter* have always been interesting phenomena to me, and I frequently watch them when the atmosphere of smoky St. Louis will permit.

On examination of the ephemeris a few days ago, I found that the shadows of the moons I and III would both be visible on the evening of October 19th. Going to my observatory on this date, and bringing *Jupiter* into the field of my 6½-inch I found both shadows on the disk.

As the position of shadows indicated that I appeared on the disk last, and further examination of the almanac showed it would pass off first, I was interested to know just how, or in what position the shadows would be in when passing each other. After waiting some seventy minutes the shadow of I merged with shadow of III, and at last became lost to view, although the indications were that it would pass slightly below the shadow of III: but owing to bad atmosphere this could not be definitely determined by observation of the shadows. In the mean time I had called my son's attention to the passing show in order to verify the question. We now turned our attention to the moons, and found that previous to the shadow contact moon I was bright, but when we lost the shadow we found that the moon was losing light rapidly, and at 8:30 the moon became a very faint point of light, showing conclusively that we had observed a partial eclipse of moon I in the shadow of moon III.

I might add that moons II, III, and IV remained bright all this time and that moon I regained its brightness about 8:40.

The eclipse was of very short duration at best, and not having been fortunate enough to observe one previous to this time I write this for the benefit of others who may be interested and ask if it be an unusual occurrence in so far as being observed frequently. Yours truly,

3021 Eads Avenue. L. BARTLETT.

GENERAL NOTES.

Members and friends of the Society are invited to aid the Committee on Publication in the work of this department. Communications to this end may be sent to FRANK SCHLESINGER, International Latitude Observatory, Ukiah, California.

Co-operation in Line-of-Sight Observations.—The number of astronomical enterprises calling for the co-operation of several observatories or observers is steadily increasing. The latest addition to the list relates to the determination of velocities in the line of sight with the spectroscope. It has been recognized for some time that observations of this kind may be subject to considerable systematic errors. In the case of variable velocity in the line of sight, for example, no safe conclusions can be drawn from the results given by different observers unless allowance is made for systematic differences. An obvious safeguard is for each observer to test his instrument by observing some body, like the Moon or the planets, whose velocity is well known in advance. Such tests have occasionally been made in the past by observers with the spectroscope, but perhaps not so often as would seem desirable. In other kinds of "observations of position," with the heliometer, for example, the observer who aims at the highest precision spends a considerable fraction *of each night* in controlling the adjustment of his instrument. Great care is no less necessary with the spectroscope, especially since experience has shown that an instrument ordinarily capable of determining velocities with a probable error well under one kilometer may, for one reason or another, occasionally become deranged so as to yield velocities ten kilometers in error.

Professor E. B. FROST, of the Yerkes Observatory, has just proposed a plan for the investigation of systematic errors which in all likelihood is destined to be of much importance in the history of the subject. The observatories at Potsdam, Poulkova, Meudon, Cape of Good Hope, Cambridge (England), the McMillin (Ohio), the Yerkes, and the Lick are represented in the scheme, so that all the observers at present engaged in this kind of work will take part. Ten stars, to be known as "fundamental velocity stars," are to be observed at least three times a year by each observer, and the results are to be promptly published, together with all collateral data. The selected stars are well distributed in Right Ascension and in Declination; they range four magnitudes in brightness, and the spectral types also differ somewhat. Known spectroscopic binaries, with one exception, have been excluded from the list. This plan is regarded as a preliminary one. "It is to be hoped," writes the proposer, "that the experience of this simple plan of co-operation may be satisfactory enough to lead to its further development in the future."

The Parallax of the Sun from Spectroscopic Observations. —It is a fascinating thought that the parallax of the Sun can be determined by means of the spectroscope. In order to compute the linear velocity of the Earth in its orbit we must first know the distance of the Sun. Conversely, if we measure the Earth's velocity, we can compute the Sun's distance (and therefore its parallax) from the equation:—

The Sun's mean distance = the Earth's mean velocity × a constant.

This constant is known with extreme accuracy. Now, if any star near the zodiac be observed with the spectroscope at the two seasons when its longitude differs from that of the Sun by 90°, we can deduce not only the velocity of the star in the line of sight, but the mean velocity of the Earth in its orbit as well. These ideas have no doubt been entertained by spectroscopists ever since the practical demonstration of the soundness of DOPPLER'S principle, but they have not been put into effect because until quite recently it has not been possible to make the observations with sufficient accuracy. In connection with the plan of co-operation which is the subject of the preceding note, Sir DAVID GILL, Director of the Cape of Good Hope Observatory, has thrown out the suggestion that, "at each observatory some star should be selected to be observed nearly throughout the whole year, so as to determine the mean velocity of the Earth's motion independently by spectroscopic means—in other words, to determine the solar parallax by spectroscopic methods. This should give us a tolerably sound measurement of the fundamental accuracy of our work." It is to be hoped that this suggestion will be generally adopted. It is not impossible that the result of such observations would be valuable as a contribution to our knowledge of the Sun's distance as well as for the reason given by

Sir DAVID GILL. Two observations, taken at two opposite seasons, of a properly chosen star, will differ by as much as 59.7 kilometers per second on account of the Earth's motion. Several spectroscopes have at the present time reached or surpassed an accuracy corresponding to a probable error of half a kilometer for a single determination of a velocity. This means that in order to reduce the probable error of the Sun's parallax to 0".01 about two hundred observations would be necessary. As these observations would be distributed among several observatories, the expectation would perhaps not be unwarranted that systematic errors would not greatly influence the result, especially when it is remembered that the observations are *differential,* and that any error which is constant for a given star would not affect the result. Furthermore, special precautions like the following might be adopted for this work: (1) The star to be observed should have a longitude near six hours or eighteen hours in order that in the spring and in the fall its longitude will differ from that of the Sun by 90°. In this way observations at extreme temperatures may be avoided. (2) Without being too far from the zodiac the star should have such a declination as to pass near the zenith. (3) The star should have the best kind of spectrum for this work (SECCHI's Type II). (4) As bright a star as possible should be chosen in order to make the exposures short. (5) The star should always be observed at nearly the same hour-angle, and therefore at nearly the same zenith-distance.

Change in the Spectrum of Nova Persei.—*Nova Persei* has steadily diminished in brightness, until now it is fainter than the ninth magnitude; that is, it emits less than the one four-thousandth part of its light at the height of its glory, in February, 1901. Ordinary spectroscopic observations upon such an object are, of course, extremely difficult, but Professor BARNARD of the Yerkes Observatory was able to show in a simple and ingenious way that the spectrum had undergone an important change toward the beginning of October. Up to that time repeated examinations of the focal-scale attached to the great 40-inch telescope showed no difference between the *Nova* and an ordinary star. But on October 6th, and some succeeding dates, Professor BARNARD found that the focal length was five or six millimeters longer for the *Nova* than for other faint stars. At the same time he noted a change in color from white to bluish-white. Professor BARNARD was led to make these observations by his earlier work on planetary nebulæ, which the *Nova* much resembles. It was in their case that he first noticed a measurable difference in focus as compared with the majority of stars. The theory of this difference is quite simple, arising from the imperfect achromatism of the objective. If we should focus in succession upon luminous objects emitting monochromatic light, we should find a regular and gradual change in focal length as we pass from one color to its neighbor in the spectrum. Of course, such a change in focus is not appreciable in a small telescope. The Yerkes telescope has a focal length of 62 feet, and is therefore pre-eminently fit for such observations.

On November 29th, Comet 1902 *b* (PERRINE) passed within two million miles of *Mercury*. As the perturbation of the comet is comparatively great at such a small distance, it is not improbable that a thorough discussion of the comet's orbit will throw additional light on the question of *Mercury's* mass. This quantity is at present quite indeterminate, more so than the mass of any other planet. A change of twenty or thirty per cent from the usually adopted value is not impossible. Observations of this comet therefore assume unusual importance.

Dr. CARL W. WIRTZ has carried out an extensive triangulation of the *Hyades* with the six-inch heliometer at the Bonn Observatory. This instrument was made by MERZ and MAHLER sixty years ago. The triangulation includes sixty-nine stars and extends over the well-known V in *Taurus* and over an equal portion of the sky immediately south. The whole area included is about eighteen square degrees, and it is the greatest single area ever triangulated. The reason for extending the work to such limits is found in the community of proper motion which attaches to nearly all the stars in the region. Dr. WIRTZ's work will, after the lapse of some years, no doubt occupy the same relation to this group as BESSEL's work does to the *Pleiades*, or WINNECKE's to *Præsepe*.

Professor WILHELM FOERSTER, Director of the Royal Observatory at Berlin, announces his intention of retiring next year. He will, however, still retain his professorship in the university.

The authorities of Williams College, Williamstown, Mass., have named Professor MILHAM as successor to the late Professor SAFFORD in the directorship of the Field Memorial Observatory at that institution.

Dr. RUSSELL TRACY CRAWFORD has resigned his place in the Berkeley Astronomical Department of the University of California, to accept a position on the examining force of the United States Civil Service Commission.

A brother of Director VAN VLECK, of the Wesleyan University Observatory, at Middletown, Conn., has given the sum of $40,000 to the university for the erection of a new observatory.

ALEXANDER KOWALSKI, astronomer at the Poulkova Observatory, died on July 6th last, at the age of forty-four years. He was born at Kasan, where his father was director of the observatory of that city. ALEXANDER KOWALSKI had been connected with the Kasan Observatory from 1882 to 1894, at which latter date he accepted a call to Poulkova. At Kasan he took part in the observations for the Astronomische Gesellschaft Catalogue of Stars (Zone 75° to 80°), in observations with the prime-vertical, and in the latitude-variation work. At Poulkova he was chiefly concerned with a new catalogue of 1000 stars which has just been completed. This catalogue is the first, we believe, to be based upon observations with the registering micrometer.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, NOVEMBER 29, 1902, AT 7:30 P.M.

President PERRINE presided. A quorum was present. The minutes of the last meeting were approved. The following members were duly elected:—

LIST OF MEMBERS ELECTED NOVEMBER 29, 1902.

Mrs. A. N. BELCHER	1298 Van Ness Ave., S. F., Cal.
Mr. WM. H. SMYTH	101 Sansome St., S. F., Cal.

to take effect January 1, 1903.

It was, upon motion,

Resolved, That the Librarian be instructed to have prepared a manuscript catalogue of the books in the Library, and that an expenditure of not to exceed $50, from the interest of the Montgomery Library Fund, be authorized for that purpose.

The report of the Committee on Membership was accepted, and the Committee, consisting of Messrs. CHAS. S. CUSHING (Chairman), CHAS. BURCKHALTER, and ARMIN O. LEUSCHNER, was authorized to proceed with the carrying out of its recommendations.

The Secretary was authorized to furnish to the members of the Publication Committee, for reference purposes and as a loan, such copies of the back numbers of the *Publications* as they may need to complete their sets.

Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE LECTURE HALL OF THE CALIFORNIA ACADEMY OF SCIENCES, NOVEMBER 29, 1902, AT 8 O'CLOCK P. M.

The meeting was called to order by President PERRINE. A quorum was present. The minutes of the last meeting were approved. The Secretary read the names of new members elected.

The following papers were presented:—

The Longitudinal Aberration of a Parabolic Mirror, by Professor W. J. HUSSEY.
Observations of the Eclipsed Moon, by Miss ROSE O'HALLORAN.
Planetary Phenomena for January and February, 1903, by Professor M McNEILL.
Observations of the Total Eclipse of the Moon, by Dr. S. D. TOWNLEY.

The Chairman then introduced the lecturer of the evening, Professor W. J. HUSSEY, Astronomer at the Lick Observatory. The subject of the lecture was "Recent Progress in Double-Star Astronomy." After giving a short historical sketch of this branch of the science, Professor HUSSEY presented in tabular form the results obtained by all observers, from the first observations by HERSCHEL down to those of the present year, and impressed his interested audience with the great difficulties encountered in obtaining accurate measures of close pairs of double stars. After exhibiting a number of slides of double-star orbits and of astronomical objects the lecturer answered various questions put by members of the Society.

The meeting then adjourned.

OFFICERS OF THE SOCIETY.

Mr. C. D. PERRINE	*President*
Mr. S. D. TOWNLEY	*First Vice-President*
Miss R. O'HALLORAN	*Second Vice-President*
Mr. CHAS. S. CUSHING	*Third Vice-President*
Mr. R. G. AITKEN Mr. F. R. ZIEL	*Secretaries*
Mr. F. R. ZIEL	*Treasurer*

Board of Directors—Messrs. AITKEN, BABCOCK, CAMPBELL, CUSHING, LEUSCHNER, MOLERA, Miss O'HALLORAN, Messrs. PERRINE, PIERSON, TOWNLEY, ZIEL.

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Committee on Publication—Messrs. AITKEN, GALLOWAY, SCHLESINGER.

Library Committee—Mr. TOWNLEY, Miss O'HALLORAN, Mr. BRASCH.

Committee on the Comet-Medal—Messrs. CAMPBELL (*ex-officio*), PIERSON, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. RUTHVEN W. PIKE.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. FELIPE VALLE.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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